

Rehabilitation Therapy Services For Older Long-Stay Clients in the Ontario  
Home Care System

by

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## **Author's Declaration**

I hereby declare that I am the sole author of this thesis.

This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

## **Abstract**

### **BACKGROUND**

Rehabilitation therapies are effective for older persons in home-based settings, and have the potential to save money for the health system, while also improving the quality of life for older adults who may otherwise be hospitalized or institutionalized. Although there is evidence that home-based rehabilitation can improve functional outcomes in older adults, research has shown that many older home care clients do not receive the rehabilitation services they need. Despite the home care sector's increasing importance within Ontario's health care system, we have a limited understanding of the population that currently utilizes these services and how these services are allocated in the province. This dissertation project aims to enhance the understanding of this domain using a large provincial data repository of home care client information (RAI-HC information system).

### **METHODS**

Using the Andersen-Newman Framework to guide this research from a conceptual standpoint, and combining it with the Cross Industry Standard Process for Data Mining (CRISP-DM) as an organizational framework, this dissertation focuses on examining data collected on older long-stay home care clients. Prior to the data mining modeling procedures, knowledge of the rehabilitation services in home care was developed through a series of semi-structured interviews with key informants. The results of this qualitative study were then used to inform quantitative analyses that included creating rehabilitation service user profiles using the K-means clustering algorithm, and the development of predictive models of rehabilitation service provision using a Random forest algorithm and multilevel models.

### **RESULTS**

Older home care clients who receive occupational therapy and physiotherapy in the Ontario Home Care System form a complex and heterogeneous client population. These services are often provided to clients following an acute event, yet many older adults who could benefit from therapy services for functional improvement and maintenance are not provided services due to limited resources. K-means clustering analyses resulted in the creation of seven profiles of rehab service users illustrating the multidimensional diversity of the service user population. Predictive models were able to identify client characteristics that are commonly associated with service provision. These models confirmed the large amount of regional variation found across the province and highlighted the differences between factors that lead to occupational therapy and physiotherapy service provision.

### **CONCLUSIONS**

Using multiple methods to systematically examine rehabilitation services for long-stay clients, new insights into the current user population and the client characteristics related to service provision were obtained. Future research activities should focus on ways to use the regularly collected standardized data to identify older long-stay home care clients who would benefit most from the rehabilitation therapy services provided by the provincial home care system.

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## **Dedication**

I dedicate this work to my elders.

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## **1.0 INTRODUCTION**

### **1.1 The Ontario Home Care System**

The home health care system in Ontario provides an assortment of services to a large number of individuals in home settings. In 2009/2010, Community Care Access Centres (OACCAC) provided 603, 535 clients with a variety of therapeutic and support services including nursing, homemaking, meal delivery, transportation, physiotherapy (PT), and occupational therapy (OT; Ontario Home Care Association, 2010). The majority (56%) of the clients who receive these services are over 65 years of age (Ontario Home Care Association, 2010). Home health services play a vital role in allowing aging individuals with complex health issues to remain at home and out of emergency rooms and long-term care facilities. As the first members of the large baby boomer cohort are beginning to reach the age of 65, the efficiency and the effectiveness of this sector of the health care system is becoming increasingly important. As this large segment of our population ages into their 70s and 80s (, the demand for supportive and therapeutic services provided by the home care system will correspondingly increase. Therefore, it is vital that we work towards optimizing the system in order to best meet the health care needs of our aging population.

The majority of clients who receive home care services receive them in a private residence; however, some home care services are delivered to clients living in a long-term care home, assisted living facility, or in supportive housing. Within the entire home care client population, clients can be separated into the following broad categories: long-stay clients, post-acute clients, children, palliative, rehabilitation, and placement clients. The majority of clients within the home-care system are long-stay clients who are expected to be on service for more than 60 days. These clients tend to be older and require services such as

personal support, homemaking, and help with activities of daily living (ADLs). These clients and the rehabilitation services that they receive (or do not receive) will be the focus of this project.

Within the province of Ontario, the home health care system has been regionally organized into 14 geographic regions referred to as Local Health Integration Networks or LHINs (Ontario Ministry of Health and Long-Term-Care, 2011). This regional division of services was designed to allow each geographic region to plan, fund, and integrate their health services in their own communities. Within each LHIN, Community Care Access Centres (CCACs) work as a single entry point for persons requires home care services. Eligibility for the delivery of home care services is determined by case managers at the CCAC who then arrange for health care providers – nurses, physiotherapists, social workers, registered dietitians, occupational therapists, speech therapists, and personal support workers – to provide a range of care and support services to individuals living within the community.

Research performed in the 1990s, prior to the creation of the LHINs in 2006, demonstrated large variation in home care service provision and utilization across the province (Coyte & Young, 1999). Due to this substantial regional variation found using data from the Canadian Institute for Health Information (CIHI) and Ontario home care system administrative databases, Coyte and colleagues recommended increase in expenditures and alternative methods of organizing, financing, and delivering home care services. A more recent study of home care services in Ontario titled *Aging in Ontario: An Institute for Clinical Evaluative Sciences Chartbook of Health Service Use by Older Adults* (Institute of Clinical and Evaluative Sciences, 2010) found significant regional differences

across Ontario in: (1) waiting times to first service provision for both long-stay and short-stay applicants; (2) time to first nursing service visit following hospital discharge; (3) times to initial RAI-HC assessment; and (4) distribution of Method for Assigning Priority Levels (MAPLe) scores for senior receiving home care services (note: MAPLe algorithm is a decision-support tool that may be used to inform choices related to allocation of home care resources and prioritization of clients needing community or facility-based services; Hirdes, Poss & Curtin-Telegdi, 2008). This study by the Institute of Clinical and Evaluative Sciences demonstrates that substantial regional variation in home care services has persisted since the creation of the LHINs and highlights the need for modifications of the system to ensure that all residents of Ontario have equal access to services.

Due to the requisite role that home care plays in the health and well-being of older adults, the Romanow Report has described home care as the “next essential service” (Romanow, 2002). With an increased policy emphasis on aging in place initiatives (Williams et al., 2009), and evidence of unmet needs in home care (Forbes, 2004; National Advisory Council on Aging, 2006; Hirdes et al., 2004) it is necessary to improve our understanding of the home care system and consider how we can better allocate limited resources to clients who are most likely to benefit from home-based services such as rehabilitation (Hirdes et al., 2008). This will be a growing challenge in Ontario as the province will have to deal with the growing health care needs of its aging populations.

## **1.2 Rehabilitation Services in Home Care**

Directly associated with the advancing age of Canadian populations, debilitating age-related disorders such as stroke and musculoskeletal disorders are increasing in incidence and prevalence (Badley & Crotty, 1995; Reginster, 2002; PHAC, 2009). For these older individuals, rehabilitation services (occupational therapy (OT) and physiotherapy (PT)) are particularly important. Rehabilitation services such as occupational therapy and physiotherapy are aimed at restoring and/or maintaining the functional autonomy of these persons.

As our health care systems shifts care from hospitals into homes, many older individuals now receive rehabilitation services once they have left the hospital system and entered the home care system. The goal of rehabilitation services in home care (through PT or OT or a combination of both), is to allow individuals to maintain or improve physical functioning, quality of life and their overall independence while remaining in the community longer (Côté & Fox, 2007). In a recent systematic review, Stolee, Lim, Wilson, & Glennly (2011) found that published studies consistently reported that home rehabilitation for older adults with musculoskeletal disorders was equal or superior to hospital based rehabilitation in nearly all patient outcomes assessed. Rehabilitation services for older adults in home care have the potential to save money for the health system downstream (by reducing falls, emergency room use, and dependencies), while also effectively improving the quality of life for people who may otherwise be hospitalized or institutionalized (Anderson, Ni Mhurchu, Brown, & Carter, 2002; Shamian, Shainblum, & Stevens 2006).

For older adults, functional difficulties can significantly impact quality of life and are associated with negative health outcomes (e.g., frailty, institutionalization, death; Gill &



Kurland, 2003; Fried et al., 1998). For home care clients, there are two rehabilitation therapy services that are commonly provided to address these limitations related to aging. Physiotherapy (PT) focuses on “improving, restoring, and maintaining functional independence and physical performance; preventing and managing pain, physical impairments, disabilities and limits to participation; and promoting fitness, health and wellness” (Canadian Institute for Health Information, 2009). Occupational therapy focuses on “enabling living, through occupation; of enabling people to perform the occupations that foster health and well-being; and of enabling a just and inclusive society so that all people may participate to their potential in the daily occupations of life” (Townsend & Polatajko, 2007, p. 372). Since aging is a significant risk factor for numerous chronic diseases, physical impairments, and disabilities, these two rehabilitation therapy services will play an important role as the health care system shifts to address the needs of an aging population.

Despite the evidence of the positive effects of rehabilitation services for older adults, many older home care clients are not provided with the rehabilitation services from which they could benefit (Borrie, Stolee, Knoefel, Wells, & Seabrook, 2001; Jaglal et al., 2003; Poss et al., 2005). Past research has demonstrated that individuals specifically identified as having rehabilitation potential often do not receive any rehabilitation therapy (up to 71%, Hirdes, et al., 2004). In addition to these findings at the level of the client, significant variation across health regions in home care rehabilitation services in Ontario has been reported. A study by Mahomed et al. (2004) found large discrepancies in rehabilitation strategies across Community Care Access Centre (CCAC) regions in the province (this study was performed prior to the development of the LHINs). Further, preliminary research by Poss (2010) demonstrated that this inter-regional variation in rehabilitation service persisted after the

creation of the LHNs and continues today. This preliminary research indicates that where an older home care client lives may determine whether or not they receive rehabilitation services, despite actual or perceived need.

Rehabilitation services providers face challenges in providing rehabilitation therapies to older persons that include an increased level of frailty, a higher prevalence of comorbidities, and the fact that disability among seniors is complex and multi-factorial, requiring knowledge and expertise from several subspecialties and professional disciplines (Hirdes, 2006; Knoefel, et al., 2003; Wells, Seabrook, Stolee, Borrie, & Knoefel, 2003). Despite these complications, rehabilitation therapies for older persons in home-based settings have been demonstrated to be successfully performed in the homes of older adults while producing similar or better outcomes than inpatient services (Gill et al., 2002; Kuisma, 2002; Crotty, Whitehead, Miller, & Gray, 2003; Gitlin, Hauck, Winter, Dennis, & Schulz, 2006; Gitlin et al., 2006; Giusti et al., 2006; Stolee et al., 2010; Stolee, Lim, Wilson, & Glenny, 2011).

### **1.3 Complexity of an Aging Client Population**

Relative to young and middle aged adults, older adults (>65 years of age) are much more likely to have multiple medical problems, multiple chronic diseases, atypical presentations of medical conditions, multiple prescription medications (polypharmacy), adverse medication reactions, cognitive impairment, and sensory impairment (CIHI, 2011; Corrette, Doubal, & Mead, 2010; Rajska-Neumann & Wiecxorowska-Tobis, 2007; Peron, Marcum, Boyce, Hanlon, & Handler, 2011; Lindsay et al., 2002; Miller, Zylstra & Standridge, 2000). These complications of aging make older adults vulnerable to rapid declines in their condition, more likely to use health services, and increases risk of both institutionalization and

mortality. (Canadian Institute for Health Information, 2011; Adams et al., 2002; Marengoni et al., 2011). This multifactorial nature of the health and well-being of our elders is leading to client populations that are challenging to manage (Murtaugh et al., 2009).

Geriatric syndromes such as frailty, age-related cognitive decline, delirium, falls, and urinary incontinence are prevalent conditions in older adults (Inouye, Studenski, Tinetti, & Kuchel, 2007). These health conditions greatly impact the quality of life and disability status of older individuals; however, there is currently a number of unsolved questions related to their etiologies, pathologies, and prevention/treatment strategies (Inouye et al., 2007). Geriatric syndromes are understood by geriatricians to be complex due to the fact that they involve multiple underlying factors, interacting pathogenetic pathways, and multiple organ systems (Inouye et al., 2007).

Embracing complexity is important when developing research strategies that are aimed at better understanding how these complex conditions can be dealt with within the health system. Traditional research methods that utilize simple linear models linking one cause to one effect cannot adequately address this complexity. Research that utilizes models and conceptualizations that embrace the interconnectedness and dynamics often found in complex systems have the potential to lead to insights and knowledge discoveries that are not possible through traditional reductionist approaches.

Due to the fact that we are entering the information age with new analytic tools being consistently developed within the information sciences (e.g., computer science, mathematics, engineering), there is great potential for knowledge discoveries and innovations in the study of health and diseases of our aging populations. Shifting away from linear, reductionist approaches to data towards new approaches from the field of data mining can assist health

researchers deal with the complexities of aging by allowing for models and conceptualizations that can account for the complexity that is inherent in the aetiologies, pathophysiologies, medical treatments, and prevention strategies for an aging population.

#### **1.4 Knowledge Discovery in Databases**

Across a wide variety of health services and medical domains, data are being collected and accumulated at a rapid pace. Information is now measured in petabytes (1 petabyte = 1 quadrillion bytes) and vast amounts of health data have accumulated in Ontario and Canada through a variety of standardized information systems (e.g., Discharge Abstract Database, National Ambulatory Care Reporting System), health surveys (e.g., Canadian Community Health Survey), cohort studies (e.g., Ontario Health Study, Canadian Longitudinal Study on Aging), and surveillance systems (e.g., Ontario Cancer Registry, Canadian Chronic Disease Surveillance System). Because of this immense build up of data, there is a great need for the development of analytical tools to assist health scientists in extracting useful information (knowledge) from the rapidly growing volumes of electronic health data.

With the computer age, data volumes have rapidly grown across all of the sciences. This increase in data has led to the new field known as “knowledge discovery in databases” (KDD). KDD refers to “the nontrivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data” (Fayyad, Piatetsky-Shapiro, and Smyth, 1996). This relatively new field has evolved from disciplines including machine learning, pattern recognition, statistics, artificial intelligence, knowledge acquisition for expert systems, data visualization, and high-performance computing (Fayyad et al., 1996).

Frequently KDD is used synonymously with the term “data mining”. However, KDD actually refers to the overall process of extracting useful knowledge from data, while data mining refers to the particular step in the KDD process where algorithms are applied to extract patterns from the data. As standard statistical techniques have shown their limitations with large databases, many health scientists are turning their attention to machine learning and data mining techniques.

The increase in the amount of electronic health data being generated had occurred within the Ontario Home Care system. In the last ten years, well over one million of the provincially mandatory collected home care assessments (RAI-HC: Resident Assessment Instrument – Home Care) have been collected on the long-stay users. The RAI-HC is a comprehensive assessment that covers multiple domains using over three hundred separate items. This information system is utilized to collect information on all long-stay users of the Ontario Home Care System. As the data are gathered from across the 14 CCACs and amalgamated within a provincial data repository, it is possible to use a knowledge discovery in databases approach to work towards the development of new knowledge of home care clients and the services that are provided to them.

This vast increase in data holdings, also known as the ‘data deluge’ and ‘big data’, has made traditional manual data analysis techniques inadequate for data analysis and knowledge discovery in the growing volumes of data (Flouris & Duffy, 2006; Mullins et al., 2006; Sibbrit & Gibberd, 2004; Fayyad & Uthurusamy, 1996). In order to utilize the data to create new knowledge of this health care user population and the services that they use, novel tools and techniques created within various information sciences outside of the health

sciences (computer sciences, mathematics, engineering) need to be developed and applied for use with electronic health information.

## **1.5 Machine Learning and Data Mining**

Previously, much of the analyses of large health system databases have been primarily descriptive, or have used traditional statistics that focus on correlations and linear models using regression techniques, although there has been some analysis of standardized assessment data using decision-tree models (James, Wiley & Fries, 2007; Hirdes, Poss & Curtin-Telegdi, 2008; Poss et al., 2010). While linear models are easily constructed and produce results that are readily interpretable, they do not adequately address the complexities that commonly occur in data that represent the health and medical characteristics of older human subjects (Mitnitski, et al., 2003).

Machine learning and data mining encompass a range of recently developed computer-based analytical tools that have emerged from an interdisciplinary field involving computer science, statistics, and artificial intelligence. These methods have been successfully applied in other domains to inform practices and improve efficiencies (e.g., marketing, investment, fraud detection, manufacturing, telecommunications; Koh & Tan, 2005; Fayyad, Piatetsky-Shapiro, and Smyth, 1996), and have great potential to provide health science and applied health researchers with powerful analytical techniques to ask new and different questions that can reveal previously unknown patterns in the growing volumes of electronic health data (Glover, 2010). Machine learning and data mining techniques can be broadly classified into three categories (Koh & Tan, 2005): (1) data description and

visualization; (2) clustering and association; and (3) classification and estimation. Below, these three broad categories will be briefly introduced.

### **Data Description and Visualization**

Description and visualization of data is an important aspect of any data mining project (Meneses & Grinstein, 2001). It involves exploring the data through examining the distribution of key attributes, relations between pairs or small numbers of attributes, and properties of significant sub-populations through simple statistical analyses and data visualizations (Chapman et al., 2001). Closely examining data can help to identify data quality problems and to help discover insights into hidden patterns and non-linear interactions. Data visualization is the process of using various techniques to transform data, information, and knowledge into a visual representation, with the goal of allowing a user to quickly and efficiently deal with large amounts of information. The ability of humans to process visual information more quickly than numerical information has commonly been attributed to the nature of the human brain where the visual system is the dominant sensory system.

Visualization of data is equally if not more important than examining basic statistical properties of data. This has been exceptionally demonstrated by Anscombe's Quartet, a celebrated illustration of the importance of visualization. In a paper titled *Graphs in Statistical Analysis*, F.J. Anscombe (1973) utilized four distinct datasets to clearly illustrate the importance of data visualization. Each of the four datasets had identical statistical properties:  $x$  average=9.0,  $y$  average=7.5, with nearly identical variances, correlations, and regression lines (to at least two decimal places; see Table 1). Based upon this knowledge,

one might think that these datasets contain similar information. However, if you were to graph the data, a different understanding results (see Figure 1). Once the four data sets have been put into graphical form, one can clearly see the potential errors that can arise from relying strictly on statistical figures (as they are easily distorted by outliers and non-linear relationships).

Typically, the visualization aspect of machine learning and data mining is not typically a published component of a study. However, with advancements in data visualization, geographic information systems, and mapping software, this will most likely change and data visualization will become an increasingly published aspect of research. An example of development in this area can be found in the work of Hans Rosling and his website [gapminder.org](http://gapminder.org). This work illustrates the potential use of data visualization to better find relationships in population health data.



**Table 1.** Anscombe's Quartet - The four datasets

I		II		III		IV	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89

Source: <http://wiki.uiowa.edu/display/bstat/Correlation>.

Each of the four datasets had identical statistical properties:  $x$  average=9.0,  $y$  average=7.5, nearly identical variances, correlations, regression lines.

**Figure 1.** Visualizations of Anscombe's Quartet

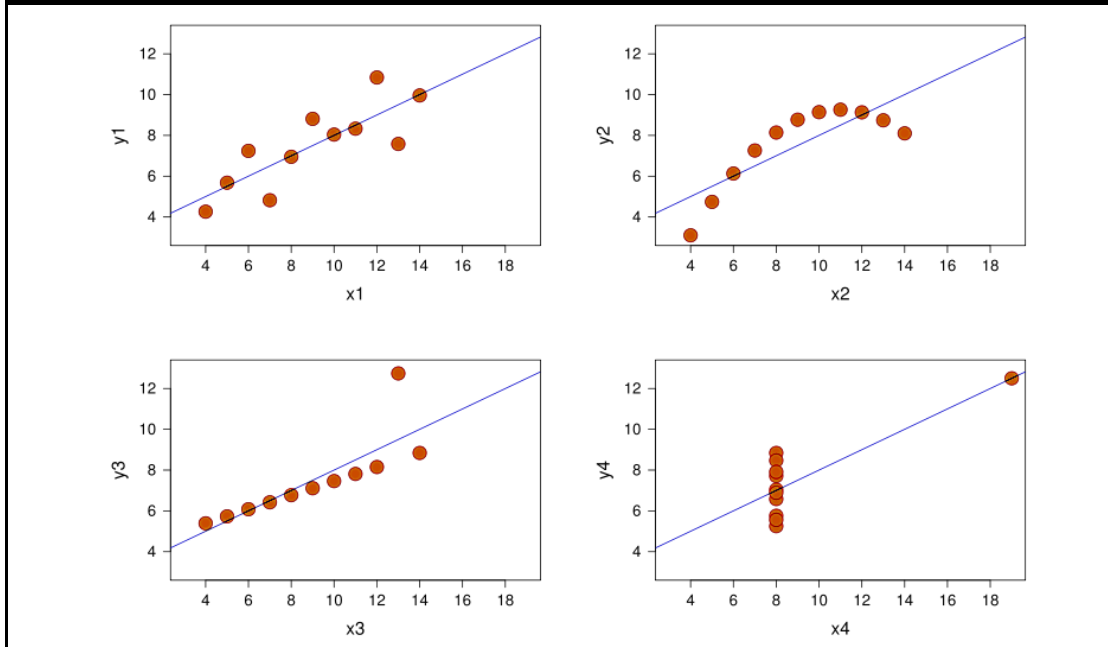


Image Source: <http://wiki.uiowa.edu/display/bstat/Correlation>

## **Association and Clustering**

In the second category of ML and DM tools, association and clustering, the objective of these algorithms is to determine how variables are related to each other. In machine learning and data mining terminology, these methods are considered unsupervised learning techniques (Kononenko & Kukar, 2007). Unsupervised learning refers to approaches to data that are not guided by any dependent variables (supervisory signals). Therefore, the typical problem approached by unsupervised learning techniques is to find hidden structures within a number of input variables. In other words, unsupervised learning techniques look to understand the data by considering the relationships between all variables. These techniques can be organized into two broad categories: (1) clustering and (2) association (Koh & Tan, 2005).

For clustering techniques, the objective is to group objects (e.g., a population of elderly patients) into homogeneous subgroups where objects within each subgroup are similar and objects belonging to different subgroups are dissimilar (Han & Kamber, 2006). There are a number of different approaches used to perform cluster analyses including K-means, mixture models, and hierarchical clustering. Of these methods, one of the most popular is the K-means algorithm. This technique works well in large datasets and is widely applied in clustering problems outside of the fields of gerontology and geriatrics. However, there are a limited number of examples where this algorithm has been applied in gerontological data. Thøgersen-Ntoumani et al. (2011) utilized the K-means algorithm in the analysis of self-report questionnaires to identify health and well-being typologies among a sample of older European adults. Their study found four clusters highlighting the heterogeneity found in the health profiles of older adults. A second example of K-means clustering was conducted by

Libon and colleagues (2010) where the K-means algorithm was applied to neuropsychological data to investigate the heterogeneity of mild cognitive impairment (MCI). The K-means algorithm was used to verify results from confirmatory factor analysis that their data indicated that three separate subtypes of MCI exist, thus illustrating the nuanced and complex nature of a common clinical entity.

Association techniques are similar to clustering in that association techniques are designed to understand patterns within data and are also considered as unsupervised learning. However, rather than constructing subgroups of objects within a data set, association techniques look to identify frequent patterns (Han & Kamber, 2006). A typical example of an association technique is the use of market basket analysis in data from grocery store shoppers. This type of analysis focuses on customer buying habits by examining correlations between the different items that customers place in their “shopping baskets”. By focusing on frequent patterns in consumer behaviour data, retailers can gain insight into which items are frequently purchased together and use this knowledge in their marketing, shelf space planning, and store design.

In the healthcare arena, association techniques can be used to understand the association between health characteristics, and subsequent service use. An example of an application of this association approach was conducted by Tai & Chiu (2009). They used association rule mining to explore the complex network of comorbidities related to ADHD using a Taiwanese national health insurance database. From their study, they discovered clinically meaningful patterns between ADHD and other psychiatric comorbidities, demonstrating the usefulness of such an approach when examining common relationships between health characteristics in large clinical databases. A second example of association rule mining in

the area of health care can be found in an article by Chen et al. (2006). This Australian study examined colorectal cancer patients and used association methods to identify the most common patterns of health characteristics for their patient population. Their results were aimed to help health professionals by identifying areas for further study when examining the causes of colorectal cancer and potential preventative factors.

### **Classification and Estimation**

The third group of machine learning and data mining techniques, and by far the most common application within data mining projects, is the use of classification and estimation. Also known as predictive modeling, this machine learning and data mining category includes multiple regression techniques that are familiar to researchers in the health sciences (e.g., logistic regression). Techniques in this category are classified as supervised learning, as they create models that relate a dependent variable (supervisory signal) with a set of predictors (Kononenko & Kukar, 2007). Predictive techniques are often separated into two distinct categories, classification and estimation, depending entirely on the target variable to be predicted. Classification refers to the prediction of a target variable that is categorical (e.g., diseased, not diseased), whereas estimation is used to predict a target variable that is continuous (e.g., length of stay or the number of service visits).

One technique that has gained some popularity in the health sciences the decision tree, also called tree-based methods. These methods are based on a form of recursive partitioning. Decision tree algorithms are used to predict continuous measures (regression trees) or categorize objects based upon each object's value on a variable of interest (target variable). These methods can be used to both describe the data set (find predictors of outcomes) or to

make predictions for new cases. An example of the application of decision trees to health data in a gerontological domain was published by Sibbritt, Byles, & Regan (2007). This study applied decision tree analysis to data from the Australian Study on Women's Health to examine predictors of functional decline in older women. Prior to conducting the decision tree analysis, bivariate analyses identified a large number of variables that were significantly associated with physical decline ( $P < 0.0001$ ) including age, falls, number of diagnoses, symptoms, doctor visits and medications, days spent in hospital, body mass index, living arrangements and social support. By applying decision trees to this same data, Sibbritt and colleagues were able to use this multivariate classification technique to identify three factors that were able to accurately predict future physical decline in a cohort of older women.

Decision trees have also been utilized in the development of decision support algorithms found within the interRAI suite of instruments including the MAPLe (Hirdes, Poss, & Curtin-Telegdi, 2008), the Cognitive Performance Scale (Morris et al., 1994), the Changes in End-stage Disease, Signs and Symptoms Scale (CHESS; Hirdes, Frijters, and Teare, 2003), the Resource Utilization Groups (RUG III; Fries et al., 1994; Hirdes, Botz, Kozak, & Lepp, 1996; Poss, Hirdes, Fries, McKillop, & Chase, 2008), and the Pressure Ulcer Risk Scale (PURS; Poss, 2010).

An extension of decision tree analysis is the Random forest algorithm. The Random forest algorithm works by building a collection of decision trees with predictions determined by taking a majority vote of all the trees that were created in the analysis (Breiman, 2001a). To improve the performance of the algorithm, each of the decision trees in a Random forest are not identical. The trees differ in that prior to building each tree, the algorithm takes a bootstrap sample (sampling with replacement) of the whole set of data, which allows for trees to be

grown from different samples from the overall population. In addition to using varying sets of data for each tree, each of the decision trees in a Random forest analysis uses a randomly selected subset from the overall pool of predictor variables. Therefore, each of the decision trees optimizes its prediction using different mixes of predictor variables. These characteristics of the Random forest approach make it a powerful algorithm that has been shown to outperform other types of predictive modeling techniques (Peng, Chuang, Kang, & Tseng, 2010; Dittman, Khoshgoftaar, Wald, & Napolitano, 2011; Maroco et al., 2011).

KDD, machine learning and data mining in health services and health research should not be considered as a replacement of traditional statistical techniques. Considering the rapidly expanding volumes of electronic health data, there is a need for development of these tools. Furthermore, due to the fact that we currently have a growing number of aging adults in Ontario and limited health care resources, novel insights that improve the efficiency and effectiveness of the health system are greatly needed.

## **2.0 DISSERTATION RATIONALE AND GENERAL METHODOLOGY**

### **2.1 Dissertation Rationale**

Significant health and quality of life benefits could be achieved for older persons through better understanding of rehabilitation services in the Ontario Home Care System. More precisely, an improved understanding of older clients, their needs, and the rehabilitation services provided to them could potentially lead to enhanced clinical decision making, improved evidence based policies, and a more efficient health care system. The overall objective of this dissertation project is to enhance understanding in this area by systematically examining a provincial data repository of comprehensive assessment data and rehabilitation service provision information of all older long-stay (> 60 days) clients using a Knowledge Discovery in Databases process.

### **2.3 Knowledge Discovery in Databases Process Model**

This dissertation will utilize a Knowledge Discovery in Databases (KDD) process model as a guide for the overall methodological design. KDD process models typically consist of a series of steps aimed to assist data mining practitioners when designing and executing a project using data to inform practice. The basic structure of the KDD process was first proposed by Fayyad and colleagues in 1996 (Fayyad et al., 1996). Since this original model in the mid-1990s, a number of different KDD process models have been developed. Review of the development and the range of KDD process models can be found in articles by Kurgan & Musilek (2006) and Mariscal, Marban, & Fernández (2010).

The process model that will guide this secondary data analysis is the Cross Industry Standardized Process for Data Mining (CRISP-DM) developed by Chapman and colleagues

(2000). The CRISP-DM is a framework that provides a functional structure that can be used to organize secondary analyses within electronic health care data. The strengths of the CRISP-DM are that it is industry neutral and tool neutral (it is not associated with any specific software) which have made it the most widely used methodology for developing data mining projects (Mariscal, Marban, & Fernández, 2010). The CRISP-DM process model allows for this dissertation project to directly blend health care services knowledge with innovative quantitative approaches, thus providing a platform that permits thorough investigation into a large provincial data repository.

## **2.4 Application of the CRISP-DM**

The CRISP-DM consists of six major phases that are outlined and briefly summarized in Table 2. Each phase consists of tasks that assist a researcher in the development of knowledge from data. From developing ‘business understanding’ (Phase 1) to the deployment of new knowledge (Phase 6), the following sections provide an overview of how this dissertation will apply the CRISP-DM to data collected from older clients within the Ontario Home Care Sector.

**Phase 1 (Business Understanding) of the CRISP-DM** focuses on developing the understanding of the research area prior to working with any data. For this dissertation project, ‘business understanding’ was developed through a qualitative research project that utilized semi-structured interviews with Community Care Access Centres case managers, policy makers, and service providers. The results of the qualitative component of this project is outlined in the manuscript: **Developing ‘Business Understanding’ in a Knowledge Discovery in Databases Project Using Semi-Structured Interviews with**



**Stakeholders from Various Perspectives.** The purpose of this study was to develop a deeper understanding of the topic area to inform and enhance the understanding and modeling of the electronic health data in Phase 4 of the CRISP-DM.

In **Phase 2 (Data Understanding)**, the focus was on acquiring, describing, and exploring the data for this secondary data analysis project. The description aspect of this phase was on the examination of the surface properties of the data (data fields, attribute ranges, quantity, format). Data exploration activities included queries and visualizations of the data including distribution of key attributes, relations between pairs and small groups of attributes, properties of significant subpopulations, and basic statistical analyses. The data analysis in the phase will identify anomalies, outliers, and missing values. These exploratory analyses were combined with the results of Phase 1 to influence the data preparation and modeling phases.

The results of Phase 2 can be found in the second manuscript within this dissertation: **Rehabilitation Service Use and Population Characteristics of Older Long-Stay Home Care Clients in the Ontario Home Care System 2005-2010.** The purpose of this study was to develop an understanding of the RAI-HC data cut and report the characteristics of the service use and user populations through a series of descriptive analyses and data visualizations. The data used for this study was RAI-HC assessments and rehabilitation service use information from every older long-stay home care clients that entered the Ontario Home Care System in the years 2005-2010.

**Phase 3 (Data Preparation)** involved selecting, cleaning, integrating, and formatting data to be used in the Phase 4. In addition to the RAI-HC assessment information, rehabilitation service use data for every client was incorporated. Using unique client

identifiers, actual service use data were linked to each client's RAI-HC. This information was dichotomized into receipt of services (1) vs. no receipt of services (0), and included the rehabilitation therapy services of occupational therapy and physiotherapy. This phase includes many steps within the database in order to format the data to suit the modeling tools to be used in Phase 4 (e.g., dichotomizing outcome measures, transforming assessment items, etc).

**Table 2.** The Six Phases of the CRISP-DM.

Phase	Description	CRISP-DM Full Phase Visualization
1. Business Understanding	<ul style="list-style-type: none"> <li>• Understand objectives and requirements from various stakeholder perspectives</li> <li>• Convert contextual knowledge into problem definitions and preliminary plans</li> </ul>	<p>The diagram illustrates the CRISP-DM process as a continuous cycle. It features six rectangular boxes arranged in a circle, connected by arrows indicating a clockwise flow: Business Understanding, Data Understanding, Data Preparation, Modeling, Evaluation, and Deployment. In the center of the cycle is a cylinder labeled 'Data'. Bidirectional arrows connect Business Understanding and Data Understanding. Arrows also show feedback loops from Data Understanding back to Business Understanding, from Modeling back to Data Understanding, from Evaluation back to Modeling, and from Deployment back to Evaluation. A large outer arrow encircles the entire process, suggesting an overall iterative nature.</p>
2. Data Understanding	<ul style="list-style-type: none"> <li>• Collect initial data</li> <li>• Create descriptions of data fields</li> <li>• Explore data</li> <li>• Verify data quality</li> </ul>	
3. Data Preparation	<ul style="list-style-type: none"> <li>• Select data for analyses</li> <li>• Clean data</li> <li>• Integrate data sources</li> <li>• Format data for Phase 4</li> </ul>	
4. Modeling	<ul style="list-style-type: none"> <li>• Data mining and machine learning modeling of problems defined in Phase 1</li> </ul>	
5. Evaluation	<ul style="list-style-type: none"> <li>• Evaluate results of modeling stage</li> <li>• Determine any issues that may not have been sufficiently considered</li> </ul>	
6. Deployment	<ul style="list-style-type: none"> <li>• Organize and present results in a way in which the stakeholders can apply it</li> </ul>	

\*Figure reprinted from Expert Systems with Applications, 38(8), Kao, Chen, & Chou. “Aseismic ability estimation of school building using predictive data mining models. 10252-10263, Copyright 2011, with permission from Elsevier.

**Phase 4 (Modeling)** consists of the activities generally known as data mining. It consists of selecting modeling techniques to address questions developed in the first two phases of the process model, and applying these techniques to the data in order to develop new knowledge. For this dissertation, two manuscripts were created for Phase 4.

**(1) K-Means Cluster Analysis Of Rehabilitation Service Users In the Home Health Care System Of Ontario: Examining the Heterogeneity of a Complex Geriatric**

**Population** This manuscript, which has been accepted for publication in the Archives of Physical Medicine and Rehabilitation, examined all older long-stay home care clients in the years 2005-2008. The purpose of this study was to examine the heterogeneity of the rehabilitation service user population, segment the population into homogeneous subgroups, and create cluster profiles for each of the identified subgroups. The K-means algorithm was applied to thirty-seven items from the RAI-HC. **(2) Predictors of Rehabilitation Service Provision for Older Long-stay Clients in the Ontario Home Care System.** In this final manuscript, logistic regression, multilevel logistic models, and Random forests were developed with in order to identify the main drivers of rehabilitation service provision for older long-stay home care clients in Ontario.

**Phase 5 (Evaluation)** is the step in the CRISP-DM where the models are assessed. In the general CRISP-DM process, if the models appear to be satisfactory, the project will then move forward and decide upon how to proceed with the results. Options include refinement of modelling procedures, development of new research questions (return to Phase 1), or deployment of results. As this is an academic dissertation project and not a standard CRISP-DM exercise in an industry location, Phase 5 will consist mainly of the oral defense of the project. However, communication with stakeholders and the supervisory committee will

occur as the models are developed to allow for refinement, which is always considered as an ongoing component of the CRISP-DM process.

**Phase 6 (Deployment)** for this project will consist of knowledge translation and dissemination activities. All results will be highlighted and presented on the InfoRehab website ([www.inforehab.uwaterloo.ca](http://www.inforehab.uwaterloo.ca)) which engages numerous stakeholders in rehabilitation and home care from across Ontario and Canada. InfoRehab is a Canadian Institutes of Health Research-funded research program directed by Dr. Paul Stolee and is aimed at enhancing musculoskeletal (MSK) rehabilitation through more effective use of health information. Stakeholders who will be provided with the results of this work include CCACs, LHINs, the Ontario Ministry of Health and Long-term Care, and rehabilitation service providers. This project will also result in manuscripts for publication in peer-reviewed journals as well as presentations at academic and industry conferences.

## **2.5 Data Source**

This KDD approach has been made possible in the Ontario home care system due to the extensive collection of comprehensive/standardized health assessment information by Community Care Access Centres (CCACs). In 2002, the RAI-HC, an assessment system designed by interRAI, was mandated for use for all potential long stay (>60 days) home care clients in Ontario. interRAI is an international, collaborative research network that develops instruments that enable the collection of high-quality data to enhance care quality across a variety of care settings including home care, long-term-care, and palliative care. This consortium includes members from more than thirty countries and “strives to promote evidence-informed clinical practice and policy decision making through the collection and

interpretation of high- quality data about the characteristics and outcomes of persons served across a variety of health and social services settings” (interRAI, 2012). Committed to improving care for persons who are disabled or medically complex, interRAI has designed assessment tools that allow for comprehensive, standardized data to be collected on individuals, allowing for care planning, outcome measurements, case mix classification, quality indicators, and decision support mechanisms (Bernabei, Venturiero, Tarsitani, & Gambassi, 2000).

The RAI-HC (Resident Assessment Instrument – Home Care) was designed for use in home care populations and contains a wide range of assessment items including demographic information, referral data, cognition, communication/hearing, vision, mood and behaviour, informal support services, physical functioning, continence, disease diagnoses, preventive health measures, nutrition/hydration status, oral health, skin condition, environmental assessment, and home care service utilization (Morris et al., 1997; Landi et al., 2000). Most clients who are expected to be long-stay have a RAI-HC assessment performed on them within two weeks of entering the home care system. Clients who were not expected to be long stay but continue to remain on service receive an assessment by day 60. Clients that remain on service are re-assessed semi-annually.

## **2.6 Governing Conceptual Framework**

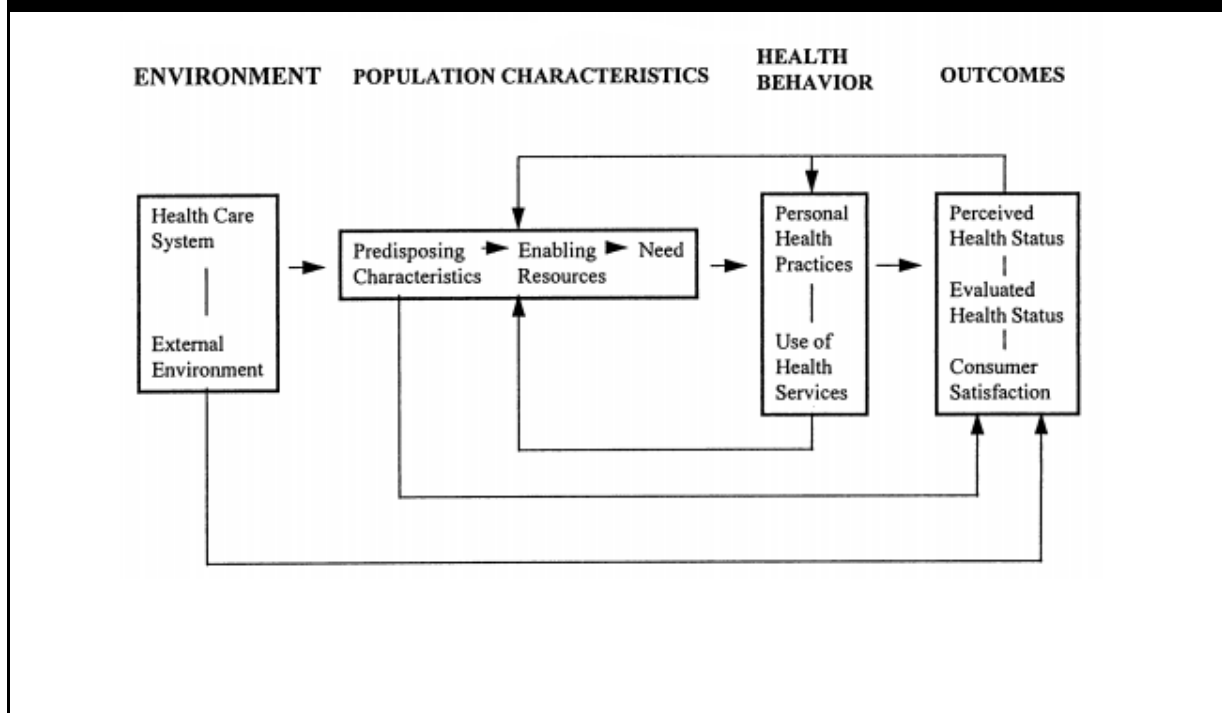
The Andersen and Newman Behavioural Model of Health Service Use has been the primary conceptual framework used to organize health services utilization research for the last forty years. Numerous research projects that aimed to understand home care utilization by the elderly have applied the Andersen-Newman framework (Kempen & Suurmeijer, 1991; Kadushin, 2004; Algera, Francke, Kerkstra, & Van Der Zee, 2004). Although it has

been adapted numerous times over the years, the basic structure of the model organizes the determinants of health service use into societal determinants, system determinants, and population characteristics with the overall aim of discovering conditions that either facilitate or impede health care service utilization (Andersen & Newman, 1973).

The population characteristics can be further broken down into predisposing characteristics, enabling factors, and need factors. Predisposing characteristics refer to the predisposition of an individual to use services; these include variables such as age, gender, race, and marital status. Enabling characteristics are variables that reflect the ability of individuals to obtain services. These can include factors such as availability of services, psychological characteristics, the ability to travel, and personal/family relationships. Need factors, which often form the most immediate cause of health service usage, refer to an individual's level of illness and disability. Within the Andersen and Newman framework, the dependent variables are operationalized as the use of health care services. As mentioned previously, this framework has seen numerous adaptations. The most recent adaptation is known as Phase 4. Phase 4 of the framework was constructed to emphasize the dynamic and recursive nature of health service use (Andersen, 1995). This adapted version of the Andersen and Newman Model was used as the conceptual framework to guide this dissertation project on rehabilitation service utilization and provision. The Andersen and Newman Model informed the formation of the interview questions and qualitative analysis for Phase 1 (Section 3.0) of the project. Questions were developed to gain understanding from key informants on how home care population characteristics, such as need factors and enabling resources, impact rehabilitation service provision. Additionally, for the quantitative portions of this dissertation, the Andersen-Newman Framework will guide the statistical and

data mining models including variable selection, research design, and model creation. Furthermore, results of the quantitative research will be reviewed through the lens of the Andersen and Newman framework.

**Figure 2. Andersen-Newman Framework Graphical Illustration**



\*Image source: Andersen, 1995

\*\*Permission to reproduce the above graphic was obtained through Sage Publications Inc.

## 2.7 Ethics Clearance

Ethics clearance from the Office of Research and Ethics at the University of Waterloo was achieved for this dissertation project on May 11<sup>th</sup>, 2012 (ORE #: 18073).



### **3.0 REHABILITATION THERAPY SERVICES FOR OLDER ADULTS IN THE ONTARIO HOME CARE SYSTEM: SEMI-STRUCTURED INTERVIEWS DESIGNED TO INFORM ANALYSES WITHIN A KNOWLEDGE DISCOVERY IN DATABASES PROJECT**

#### **Overview**

##### **BACKGROUND**

Despite the fact that rehabilitation therapy services are an essential component of the Ontario Home Care System, there is limited understanding of how these services are being provided to the aging home care client population. The aim of the study is to develop understanding of rehabilitation therapy service provision for older adults through a series of semi-structured interviews with variety of stakeholders. The results of this qualitative study will be utilized to inform and guide quantitative analyses of a provincial data repository within a Knowledge Discovery in Databases project.

##### **DESIGN**

Semi-structured interviews were conducted with 10 key informants from the Ontario Home Health Care System. Stratified purposeful sampling was conducted to gain information from three perspectives on rehabilitation services. Transcripts of interviews were analyzed in NVIVO 8 using a thematic analysis method.

##### **RESULTS**

In total, ten interviews were conducted with stakeholders from three different perspectives on the home care system: case managers, service providers, and system level stakeholders. Three themes were identified: Drivers, Challenges, and Decision Making. Findings include information on what aspects drive the provision of occupational therapy and physiotherapy for older adults, the reactive nature of therapy services in home care, and the need for novel decision support services for case managers.

##### **CONCLUSIONS**

The results of this study provided insight into the rehabilitation services for older adults in the Ontario Home Care System that can assist the analysis of provincial assessment data and knowledge translation activities.

### **3.1 Introduction**

Home care is becoming an increasingly integral component of the Ontario health system as the population is aging, the prevalence of chronic diseases and impairments of aging are rising, and patients in hospitals are being sent home after shorter lengths of stay. Home care services play a critical role in managing the transition between community and institutional living for older individuals (Romanow, 2002). Within Ontario, the provincial home care system provides a wide variety of health care and support services to individuals within their homes with the majority of its clients over the age of 65. In addition to the two most highly provided services of nurses and personal support, rehabilitation therapy services (Occupational Therapy and Physiotherapy) are provided to clients within their homes. Physiotherapy (PT) focuses on “improving, restoring, and maintaining functional independence and physical performance; preventing and managing pain, physical impairments, disabilities and limits to participation; and promoting fitness, health and wellness” (Canadian Institute for Health Information, 2009). Occupational therapy focuses on “enabling living, through occupation; of enabling people to perform the occupations that foster health and well-being; and of enabling a just and inclusive society so that all people may participate to their potential in the daily occupations of life” (Townsend & Polatajko, 2007, p. 372). These two rehabilitation therapy services are particularly vital for older adults since aging is a significant risk factor for numerous chronic diseases, physical impairments, and disabilities.

Despite the growing and clear importance of rehabilitation services within the home care system, there is a limited understanding about how these services are allocated to older adults across the province. This qualitative study aimed to build knowledge of rehabilitation

services that are provided to older adults in the Ontario Home Care System through semi-structured interviews with a variety of stakeholders. This study was designed as a core component of a larger study, a Knowledge Discovery in Databases project. More specifically, the results will be used to inform and guide a series of quantitative analyses of a provincial data repository containing clinical assessments (RAI-HC) from approximately 300 000 home care clients aged 65 and older.

## **Home Care**

In the province of Ontario, Community Care Access Centres (CCACs) provide a point of access for home health care and support services and also coordinate long-term care placement. In this role as a gatekeeper, CCACs assess potential home care clients using standardized assessment tools (i.e., interRAI Contact Assessment & RAI-HC) and then, if appropriate, arrange for visiting health professional and assistive services to work with clients in their homes. The home health services that are arranged and coordinated by Community Care Access Centres include nursing, physiotherapy, occupational therapy, speech-language therapy, dietician services, pharmacy services, diagnostic and laboratory services, respiratory therapy, social work, personal support and homemaking (OHCA, 2012). These services are utilized to support clients in a wide variety of ways including improving their ability to remain independent and in their homes for as long as possible, reducing length of stay in and need for admission to hospitals, and supporting people who are nearing the end of their life.

In order to determine what services a home care client requires, CCACs employ case managers who assess client eligibility for services and play an active role in developing,

monitoring, and adjusting service plans as required. After a client has been through the intake process and has entered the home care system, a CCAC case manager conducts an assessment of the client's health characteristics and needs. In Ontario, this assessment is conducted using interRAI instruments (Hirdes, 2006). In 2002, the provincial government mandated the use of the RAI-HC for any clients who are considered to be long-stay clients, or for clients who have been on service for more than 60 days (Hirdes, 2006).

The RAI-HC instrument collects a wide variety of information including demographic items, referral information, health characteristics, functional characteristics, available support, home environment characteristics, and medical use (Morris et al., 1997; Landi et al., 2000). Once a client has been assessed using the RAI-HC, case managers then use this comprehensive information to develop client care plans and to complete the ordering of professional services from service provider organizations. In addition to providing professional health and supportive services, CCACs also provide assistance to clients in arranging medical supplies and dressings, hospital and sickroom equipment, and any laboratory and diagnostic services that are required while one remains at their home within their community.

In the current Ontario Home Care System, assistive and professional health services are contracted out by the CCAC to service provider organizations. The system is based upon a managed competition model where private for-profit provider agencies compete directly with private not-for-profit provider agencies through a competitive bidding process (Randall, 2007). Service providers employ thousands of personal support workers, physiotherapists, nurses, occupational therapists, and other health professionals in order to deliver care to individuals within their homes across the entire province. In 2009/10, 29 419 559 hours of

care were delivered to clients through the CCACs and by the numerous service provider organizations (Ontario Home Care Association, 2012). The majority of home health care services fall into the category of personal support (69%). Personal support refers to a range of essential daily activities that help maintain a client's personal well-being. The employees that conduct this work have a variety of designations including personal support workers (PSWs), health care aides, personal care workers, and attendants. These workers provide assistance with essential activities such as personal hygiene (bathing, mouth care, skin care) and activities of daily living (dressing, eating, toileting). The second most provided service in 2009/2010 in the Ontario Home Care System was nursing (OHCA, 2012). Nurses perform a range of services for home care clients including medical and post-surgical care, palliative care, counselling, education, and assessment. After personal support work and nursing, occupational therapists (OTs) and physiotherapists (PTs) provide the next largest amounts of services to home care clients: 1.7% and 1.6% respectively in 2009/10 (OHCA, 2012). While 3.3% of all services may seem relatively small, these services account for over 900 000 visits/hours across Ontario.

### **Rehabilitation Therapy Services**

The goal of rehabilitation therapy services (OT & PT) in home care is to assist individuals in improving or maintaining physical functioning, quality of life, and their overall independence while remaining in the community longer (Côté & Fox, 2007).

Research studies have produced evidence that OT and PT can be conducted for older persons in home-based settings while producing similar or better outcomes than inpatient services (Gill et al., 2002; Kuisma, 2002; Crotty, Whitehead, Miller, & Gray, 2003; Gitlin, Hauck,

Winter, Dennis, & Schulz, 2006; Gitlin et al., 2006; Giusti et al., 2006; Stolee, Lim, Wilson, & Glenny, 2011). In the upcoming years, demand for rehabilitation therapy services will continue to increase in Ontario due to factors such as: (1) overall population growth, (2) increasing rates of chronic and complex conditions, along with changes in hospital discharge patterns, (3) increasing public expectation, and (4) advances in treatment and management of diseases and conditions (Landry, Jaglal, Wodchis, Raman, & Cott, 2008).

Despite the large amounts of rehabilitation therapy services that are currently provided in the Ontario Home Care System and the important role they play in the health and well-being of older adults, we have a limited understanding of how rehabilitation services are being provided to older long-stay home care clients. This study aimed to build knowledge of this issue through engaging a variety of stakeholders from different perspectives within the Ontario Home Care System. Semi-structured interviews were conducted with stakeholders from varying perspectives across the Ontario Home Care System. This current study was designed as an integral component of building understanding for a Knowledge Discovery in Databases (KDD) project.

Knowledge Discovery in Databases (KDD) is the nontrivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data (Fayyad, Piatetsky-Shapiro, and Smyth, 1996). This type of approach typically takes place on large volumes of electronic data and through a process that involves a series of steps that are interactive and iterative. Steps in the KDD process include developing domain knowledge, selecting and cleaning data, data mining, and knowledge deployment. This process has been standardized by numerous groups and the most popular process model to date has been the

Cross-Industry Standard Process for Data Mining (CRISP-DM; Kurgan & Musilek, 2006). The CRISP-DM (Chapman et al., 2000) consists of six phases.

- 1) Business Understanding,
- 2) Data Understanding,
- 3) Data Preparation,
- 4) Modeling,
- 5) Evaluation,
- 6) Deployment.

This qualitative study will be utilized within the “Business Understanding” phase of the CRISP-DM project that focuses on a provincial data repository. This KDD approach that combines qualitative and quantitative analyses is comparable to a sequential mixed methods research project where the results of this qualitative study in Phase 1 will be used to inform and enhance the quantitative analyses in Phase 4 (Morgan, 1998).

The results of the qualitative research will inform variable selection, analytic strategies, choice of dependent variables, and the interpretation of the quantitative projects that occur later in the thesis. These quantitative analyses will be conducted using data collected using the RAI-HC assessment tool. The RAI-HC has been mandated for use for assessment on all long-stay clients within the Ontario Home Care System since 2002. In addition to being strictly an assessment tool, the RAI-HC information system also provides outputs to support clinical decision making including Clinical Assessment Protocols (CAPs) and a variety of outcome scales. CAPs are designed to help the case manager focus on key issues identified during the RAI-HC assessment process, so that decisions as to whether and how to intervene can be explored. Outcome scales are also embedded within the RAI-HC and can assist in the evaluation of a client’s clinical status. Examples of these scales include the Cognitive Performance Scale (CPS; Morris et al., 1994), Changes in Health, End Stage Disease, Signs and Symptoms Scale (CHESS; Hirdes, Frijters & Teare, 2003), the

Depression Rating Scale (DRS; Burrow, Morris, Simon, Hirdes, & Phillip, 2000), and the ADL Hierarchy Scale (Morris, Fries, & Morris, 1999). The CAPs and the outcome scales were discussed with the key informants during semi-structured the interviews.

The aim of this qualitative study was to develop an understanding of decisions revolving around the provision of rehabilitation services for older home care clients. The results will be used to guide and inform multiple analyses of a provincial database of RAI-HC assessments.

### **3.2 Methods**

This study aims to enhance the understanding of rehabilitation services for older adults through the use thematic analysis in data collected through semi-structured interviews with key informants from the Ontario Home Care System. Thematic analysis is a method that can be used to identify, analyze and report patterns within qualitative data (Braun & Clarke, 2006).

#### **Sampling and Recruitment**

Stratified purposeful sampling (Patton, 2001) was chosen as the approach for sampling and was conducted between February 2012 and June 2012. A stratified purposeful sampling approach was selected for this project as the aim of the research is to gather insights into a specific phenomenon from multiple perspectives. Using a stratified approach allowed for a well-rounded view of the research question as it permits for the collection of data from three varying informed perspectives. The perspectives that were desired in this study were those of persons involved in resource allocation decisions at the system level (policy-makers) and individual client level (case managers), as well as those individuals on



the front line who provide the rehabilitation therapy services (employees of therapy provider organizations). Individuals from within InfoRehab network of collaborators ([www.inforehab.uwaterloo.ca](http://www.inforehab.uwaterloo.ca)) were recruited through a standardized email communication (see Appendix 4) through an advertisement in the InfoRehab newsletter. InfoRehab is a Canadian Institutes of Health Research-funded research program directed by Dr. Paul Stolee and is aimed at enhancing musculoskeletal (MSK) rehabilitation through more effective use of health information.

The case manager stratum was chosen due their role in decision making within the home care system. Eligibility for home care services is determined by CCAC case managers who develop care plans using information that is gathered through the RAI-HC information system. In this process, case managers are directly responsible for decisions related to the provision of both OT and PT to home care clients. Therefore, case managers provided a perspective in this study that directly relates to the decision-making processes related to rehabilitation therapy services in the Ontario Home Care System. The second stratum of participants, employees of service provider organizations, was chosen due to their direct interactions when providing rehabilitation services to home care clients. These participants provide a perspective from the front lines of care as well as an informed view in relation to rehabilitation therapies. The third and final stratum includes key informants who have a systems perspective; those that look at the home care system as a whole. In each case, participants were approached by email or phone and invited to participate in the study. The sample size for this project of 8-12 individuals was determined primarily for logistical reasons (limited time for completion of a thesis project) and by recommendation of the supervisory committee. As the aim of this study was to inform quantitative analyses of

secondary data, a large sample size for the qualitative study was not required. Home care clients were intentionally not included as key informants. Because the focus of this project is to better understand decisions made from within the system, it is believed that service users would not be able to provide feedback that fits within the scope of this project.

### **Data Collection**

The data collection method that was chosen for this qualitative project was semi-structured interviews. These interviews were performed with participants from the three strata mentioned previously. Interviews took place both face-to-face at convenient locations for key informants as well as via telephone. Each interview was digitally recorded for transcription purposes. All interviews were conducted by the author and took place in English. In order to guide and assist the interviewer, an interview guide was created consisting of a variety of questions related to the problem domain. This interview guide can be found in Appendix 3.

### **Data Analysis**

Qualitative data collected in the interviews consisted of verbatim transcripts of each of the interviews. Transcription was performed by an outside company and each transcript was checked against original recordings for accuracy. Transcripts were organized and analysed using the qualitative analysis software NVivo 8. All interview data were analyzed using thematic analysis outlined by Braun & Clarke (2006). According to Braun and Clarke (2006), thematic analysis of interview data can be broken down into six phases. The first phase consisted of becoming familiar with the data. Prior to any coding, each interview was read to build familiarity with the depth and breadth of the content. During this initial

examination of the data, notes were taken to develop a basis for future coding. As the interviews were conducted by the same individual performing the analyses, this initial stage was directly informed by prior knowledge of the data.

Phase 2 consisted of generating the initial codes from the data. The entire data set was systematically worked through with full and equal attention given to all of the data collected. Interesting aspects in the data items were identified and repeated patterns were pulled out. To begin this phase, deductive coding, also known as directed coding, was performed in relation to pre-established nodes that were developed within the interview guide and the interview checklist. In the third phase of the analytic process, codes were collated into potential themes. Inductive coding, an approach based on the data rather than a set of predetermined nodes was applied within this phase in order to fully develop the resulting themes (Patton, 2002).

Phase 4 involved reviewing the themes to check how they worked in relation to the coded extracts and the entire data set. This involved going through extracts from each of the themes to ensure that there was enough data to support a theme, or contrastingly, if there was enough data to justify further segmentation of the themes. Phase 5 involved defining and naming the themes. This phase was fully completed in parallel with the final phase of this process: the production of this manuscript.

### **Ethical Considerations**

Ethics clearance for this study was obtained from the University of Waterloo's Office of Research. Prior to each interview, participants were briefed about the purpose of the study, the presence of a digital recorder, and their right to withdraw participation or data at

any time. Furthermore, all interviewees were advised of the confidentiality and anonymity of their responses. Names associated with each of the quotes are not the true names of the participants. Participant information and interview data were kept in a secure location, or on a password encrypted hard drive.

### 3.3 Results

In total, ten individuals were interviewed for this project. The participants were able to provide their view on home care rehabilitation therapy services for older adults from their perspective based on their role in relation to the Ontario Home Care System. This included individuals involved in case management (3), service provision (3), and policy makers (4).

<b>Strata</b>	<b>Number of Interviews</b>
CCAC Case Manager	3
Service Provider	3
Policy Makers	4

The findings revealed a range of issues related to rehabilitation services for older adults in the Ontario Home Care System. After reviewing the data and performing the thematic analysis, three key themes emerged from within the data:

1. **Client Level Drivers of Rehabilitation Therapy Service Provision:** Factors and characteristics related to the client that were related to OT and PT service provision.
2. **Challenges of Providing Rehabilitation Therapy Services in Home Care:** Issues related to the provision of OT and PT services.
3. **Decision Making in Rehabilitation Therapy Service Allocation:** Aspects related to the decision making process for older clients.

The findings for each of the themes are presented in separate sections, however, due to the complexity of the home care system and the question at hand, some overlap between themes does exist. Within each of the three themes outlined above, subthemes were also developed. All quotes that have been included in this manuscript were pulled directly out of the data in order to illustrate each of the themes and subthemes. Table 4 provides a summary of the three themes and ten subthemes.

<b>Table 4. Themes and Subthemes</b>	
<b>Theme</b>	<b>Subthemes</b>
Client Level Drivers of Rehabilitation Therapy Service Provision	<ul style="list-style-type: none"> <li>○ Reactive approach</li> <li>○ Risk and Functional Needs</li> <li>○ Conditions and Diseases</li> </ul>
Challenges of Providing Rehabilitation Therapy Services in Home Care	<ul style="list-style-type: none"> <li>○ Lack of Resources</li> <li>○ Human Resource Issues</li> <li>○ Regional Differences</li> <li>○ Cognition</li> <li>○ Multimorbidity</li> </ul>
Decision Making in Rehabilitation Therapy Service Allocation	<ul style="list-style-type: none"> <li>○ Challenges</li> <li>○ Information Systems</li> </ul>

### **Client Level Drivers of Rehabilitation Therapy Service Provision**

#### **Reactive approach**

Within the semi-structured interviews, multiple sources spoke of how rehabilitation services in home care are targeted more towards individuals who have suffered an acute injury or illness, rather than to help those with long-term chronic illnesses. In other words, rehabilitation therapy services are thought to be used in a reactive way, and older adults who

could potentially benefit from service provision but do not clearly require it, due to an surgery or hospitalization, are left untreated. Rehabilitation services are rarely used in a proactive way to address functional decline and despite evidence of the potential benefits to older clients, these individuals often do not receive therapy services until after they have had some sort of an acute incident (fall, hospitalization, hip fracture).

“It is sort of like a band aid approach. You kind of go in and you treat issues that you could have prevented if you got the services beforehand.” – Anna

“A lot of the PT services are focused on orthopedic, rehab, post op fractures...OT focuses a lot on home safety assessments”. -Jillian

### **Risk and Functional Needs**

According to the participants of this study, risk of adverse events was one of the main drivers of both PT and OT service provision. OT and PT are both utilized to ensure client safety in their home and to improve their mobility in order to reduce risk of further accidents. Therefore, rather than using PT and OT in their traditional roles of aiming to get clients to their ideal functioning state, these services are mostly used to protect the clients from using acute services in the future. One participant clearly pointed out that this type of approach within the Ontario Home Care System does not directly match the traditional use of rehabilitation therapy services.

“It is more managing the symptoms and making sure that they are safe at home and then that’s all the visits or the time that you are there for allows you to do. So you have got to make sure that the client is safe, a sort of risk aversion, making sure that they are not at risk at that point...but then it is not really rehab. What most people consider rehab is to get the client to their optimal state. That is not really what the therapy services do right now in the home care system.”- Anna

Most of the interviewees, with an extra emphasis from the case managers, noted that the decision to provide rehabilitation therapy services is based on functional needs of the

elderly clients. These functional needs are assessed by the case managers using the RAI-HC. The case manager will then use that information, in addition to their case notes, to decide upon what services to allocate to the client. For rehabilitation therapy services, case managers reported that they based their decisions only on functional status while disease diagnoses and multiple co-morbidities were consistently reported to not directly impact the decision to provide therapy services.

“It’s totally based on their functional needs not about diagnosis. So we don’t have any category that says you know this client has MS or has I don’t know any other kind of issue, dementia, Alzheimer’s...and then they automatically get service. They have to actually have a functional need and then they get OT or PT.” - Holly

### **Conditions and Diseases**

Although the decisions to provide services were considered to be based mainly on functional needs, common ailments were also considered as drivers of service provision. Due to the complexity and the nature of rehabilitation services for older adults, a wide range of reasons were given for conditions and diseases that lead to the provision of rehabilitation services. For PT, the interviewees indicated that it is mostly related to issue of mobility and that many of the home care clients who receive these services are for post-operative care after receiving a knee or hip replacement. Further conditions mentioned by participants included falls, de-conditioning, and palliative care. It was mentioned by multiple participants that OT is primarily used in the home care system to perform home safety evaluations and also for medical equipment purposes.

“Most people do get more of the hip and knee replacement. That is sort of a top priority for rehab, and it is really anybody in terms of just having some mild motor condition who might need some mobility assessment. Our OT unfortunately right now it’s really focussed on jut home safety and equipment purposes.” – Kim

“For physiotherapy, [drivers] would be falls but then there are also the acute issues. So orthopedic surgeries like total hip replacement, total knee replacement.”-Anna

## **Challenges**

### **High Demand and Lack Of Resources**

One of the most common challenges in providing rehabilitation therapy services to older clients was the lack of resources in relation to the large amount of demand/need. Due to population aging, a great number of home care clients have mobility and functional independence issues. Therefore, these older home care clients could potentially benefit from receiving some rehabilitation therapy services. However, due to the lack of resources within the home care system, many older individuals do not receive OT or PT despite their functional needs.

“They are clearly prioritizing getting people out of the hospital as soon as they don’t need to be there and into the home. How they’re enabling that quicker discharge is to frontload them with services to ensure that they’re... that transition is done well and the client is safe. Is that being done at the expense of community dwelling residences? Because we know there’s only a finite amount of resources, nobody’s thrown enough money at them to say you know, double what you’re giving people coming home from hospital and you can continue to provide the same level of service for people in communities” – Leah

“The system is working so that everybody can’t have a prevention rehab because we don’t have enough resources”-Brianna

“Many of those resources that typically would have been allocated to community dwelling residents were now being used up front for getting people home quicker”-Leah

Numerous participants within this study spoke to the fact the home care system differs from other care settings (e.g., hospitals, long-term-care facilities); home care should not be considered as the only point of access to health/medical/support services. OT and PT



can be provided through community-based services (e.g. outpatient clinics, group settings) and through private payments to providers.

“And just because you are in the community, does that mean that that should be homecare client? Or should we be exploring other types of creative outlets to provide people with rehab such as a community center?” -Kim

“Yeah but what is happening in \_\_\_\_\_ is that we are having more outpatient programs open up so we are going to start to see that the younger population who are more independent are going to go to outpatient clinics and we are really just going to focus on those frail individuals home bound who can't get out to outpatient services.” -Kim

## **Human Resources**

Human resources issues were identified as a challenge in a variety of ways for providing rehabilitation therapy services to older adults. Firstly, it was noted that the background of case managers and their familiarity with the availability of services within the region can impact their decisions related to the provision of OT and PT services. If case managers are not familiar with how rehabilitation therapy services may be used for their clients' issues, clients may not be allocated with PT or OT despite their potential to benefit. Therefore, a case manager's background, as well as their level of experience, can directly impact exactly what type of services are provided to older long-stay home care clients.

“...we are also struggling with how do you identify who gets rehab because everyone has a different appreciation of rehab...because not all the case managers are rehab professionals, and even within rehab professionals it depends on what population you have worked with.” – Kim

A second human resource issue is related to the geographic location of a client's home. For clients who live in rural areas, it can be challenging to find professionals who are able and willing to work in the remote area. If professionals do not reside in a given rural

area, therapists will have to travel to the area to provide care, which raises problems related to availability of professionals, transportation time, and the timeliness of services that they provide.

“There is a huge challenge in terms of having professional services available in some of those more desolate areas. So it is really hard. It is like the problem with physicians; it is parallel right? So professionals going into some of these areas that are just not popular places to practice, you have a lot of trouble servicing clients. So priority timelines for example, you know, if you use the same priority timeline across the board and you have low volume and you have people spread out all over the place, how do you meet that 48 hours priority timing in this area? You know it can be very difficult, compared to downtown Toronto or Kitchener-Waterloo.”-Anna

A third human resource issue that was raised was related to communication between different professionals and case managers. Communication between these groups is a challenge as they often work for different agencies and they are rarely in the client’s care environment at the same time. When therapists conduct their work, the case manager and other care providers will not be onsite. Therefore, if any issues come up during treatment or assessment, communication with the other members of the client’s care team can be a problem.

“The only way I have interaction with the case manager, in the meantime, from the time I receive the referral, is if I have a concern, then I will try and call them to say I think you know, you might want to go in to reassess because of A, B or C, or you might want to consider putting an OT in cause there's real safety concerns.” - Leah

### **Regional Characteristics**

For participants across all three strata, the characteristics of a health region came up as a potential challenge for providing rehabilitation therapy services. First and foremost, as mentioned in the above human resources section, where a client lives can be challenging.

Clients living in rural areas can have issues accessing the OT and PT services due to the lack of professionals in their community or due to the remoteness of their home.

“Rural versus urban, there is a big difference. So, when you look at isolation of rural clients, accessibility to services, their accessibility is far more limited. So whether you live in the city or live in a rural district, you should have access to OHIP funded physiotherapy services for follow-up. If you live in a rural setting where you are nowhere near a clinic but you get the same number of PT visits for the same issue as somebody in the city, who can then follow-up with a clinic and easily access it...whereas this rural person would have to sit in the car for two hours to get to a clinic. Travel would then counter whatever therapy they might get because it is two hours there, two hours back. Sometimes you have to look at the unique needs of geographical areas.”-Anna

“Well transportation issues for clients, and well you know for us even too (service providers), for us to have access to patient settings is difficult because of the transportation issues and the weather in that particularly in that area down by the lake the roads are often closed periodically in the Winter so it’s difficult to access service.”-Jillian

Another challenge that was raised by participants was the cognitive status of these older adults. For an aging population, it is fairly common for older home care clients to have issues with cognitive decline. Although the interviews contained no references that pointed towards cognitive impairment as an outright barrier for clients to receive rehabilitation therapy services, declining cognition was mentioned to impact decisions regarding PT allocation due to the nature of the service. Much of PT is self-directed and requires the client to practice a program that was developed by the therapist. This can be challenging for a client if they suffer from cognitive impairments and if their care givers are not available or capable of assisting in rehabilitation therapy activities.

“Well a lot of the programming is self-directed so if they can’t follow an exercise program, it’s limited to what we can offer them through the CCAC framework.”  
– Jillian

A third challenge for providing OT and PT to Ontario's older population is the existence of multimorbidities in the home care client population. Multimorbidity is the co-existence of two or more diseases. From the ten interviews, multimorbidity was considered as something that did not greatly impact the decision to provide rehabilitation therapy services. As mentioned previously, case managers generally base their decisions to allocate rehabilitation therapies on functional need. Therefore, the number of diagnoses is considered irrelevant to this decision making process. However, the interviewees who were service providers did indicate that multimorbidity can impact what therapies are provided, how they are provided, and the effectiveness and efficiency of these therapies.

“It doesn't mean that you are going to get more visits or more time, it just means that your focus might be different than what they have initially set out for you.”

“As we look at the new senior population and you know this; most of them have comorbidities. Not one person has one condition. So how do we provide rehab to these individuals? Is it based on diagnosis anymore or do we start to look at our approach based on the function of the client” – Kim

## **Decision making**

### **Case Managers and Clinical Care Pathways**

One issue that was raised by both case managers and by service providers was the impact of a case manager's training on their decision making with regards to the services they choose to provide to a client. While this was also covered in the Human Resources section, this issue also plays a significant role in the decision making process. For example, the background of many case managers is nursing. Therefore, these case managers are likely to approach decisions for allocation of home care services from a nursing perspective. This can impact how the case manager perceives a client's needs and how they believe his/her

needs should be addressed by service providers. Alternatively, if a case manager comes from a PT or OT background, decisions on how and what they allocate to clients may differ.

“So often what happens is case managers will do one of two things. They will either underservice that client because their lack of knowledge related to the rehab component, or over service as a means of compensating to make sure that every “i” is dotted and “t” is crossed.”-Tina

A second issue within this subtheme are clinical care pathways. For certain diagnoses and clinical issues, developing clinical care pathways that involve rehabilitation therapy services is relatively well-established and clear (e.g., total hip replacement, stroke). In contrast, developing clinical care pathways for complex frail older persons is complicated by the large amount of complexity (e.g., multimorbidity, heterogeneous mix of needs, polypharmacy) involved in providing appropriate and effective health care. Due to the lack of clarity and lack of evidence for care pathways for complex frail older clients, making informed decisions on what type of services are provided can prove to be challenging.

“For the most part, the path or the journey of fractured hip patients is fairly predictable. For sure, total hip and knee replacement patients, we know their path. I mean they’re on a clear clinical care pathway. They’re very predictable. And stroke patients are also fairly predictable. It’s those other patients. It’s the medically complex, the frail elderly that we don’t necessarily know what their outcome is going to be and we don’t have a clear sense of their trajectory. We know that stroke patients are going to improve. We know that fractured hip patients are going to improve. But it’s the other patients that tend to fluctuate and are a little bit more complicated that, in my experience, had trouble accessing rehabilitation services.” –Emily

A third issue within this subtheme was the priority system used to order clients in terms of urgency for physiotherapy services. When the decision has been made to provide physiotherapy to a home care client, a client receives a priority classification that indicates to the service provider the time frame they have in which to provide services. This priority

system classifies individuals based upon their risk status and the urgency to receive care. Although it is unclear exactly how exactly risk is identified by the case managers, the current system tends to prioritize home care clients that come from the hospital after an acute episode or surgery. This prioritization of post-acute clients is due to the easily perceived need for therapy for these clients. Typically, older long-stay clients who suffer from chronic impairments and have been identified to have the potential to benefit from rehabilitation therapies receive a low priority level. Due to the lack of resources in the system, individuals with low priority level for physiotherapy services rarely receive those services.

### **Information Systems**

Participants in this study were clear that the current CAPs within the RAI-HC information system related to rehabilitation therapy services are not currently utilized due to their poor sensitivity and specificity. Essentially, due to the nature of the care population (typically older adults with functional impairments), many if not most home care clients are likely to benefit from rehabilitation therapy services. Therefore, because the CAPs were designed to indicate potential for clients to benefit, these CAPs were reportedly triggered for a large proportion of the population. As a result, the CAPs are not seen as being helpful to case managers during decision making processes.

“Well we don’t use the rehab CAP because it triggers for everyone.”

-Kim

“It is not helpful from a management perspective to say everybody, or 80% of your population needs rehab.”-Kim

“When you do look at RAI data or look at any of the evidence, everyone practically would trigger a need for rehab and this is not realistic. There is just not that capacity to provide all that service.”-Kim

Also discussed in the interviews was the interest in having further decision support systems developed within the RAI-HC to help the decision making process around PT and OT service allocation for older adults. Participants were interested in the potential for new scales or measures that could identify not only a client's need for specific services, but which could also set a priority level in order to avoid the perceived limitations of the current CAPs that are related to rehabilitation services.

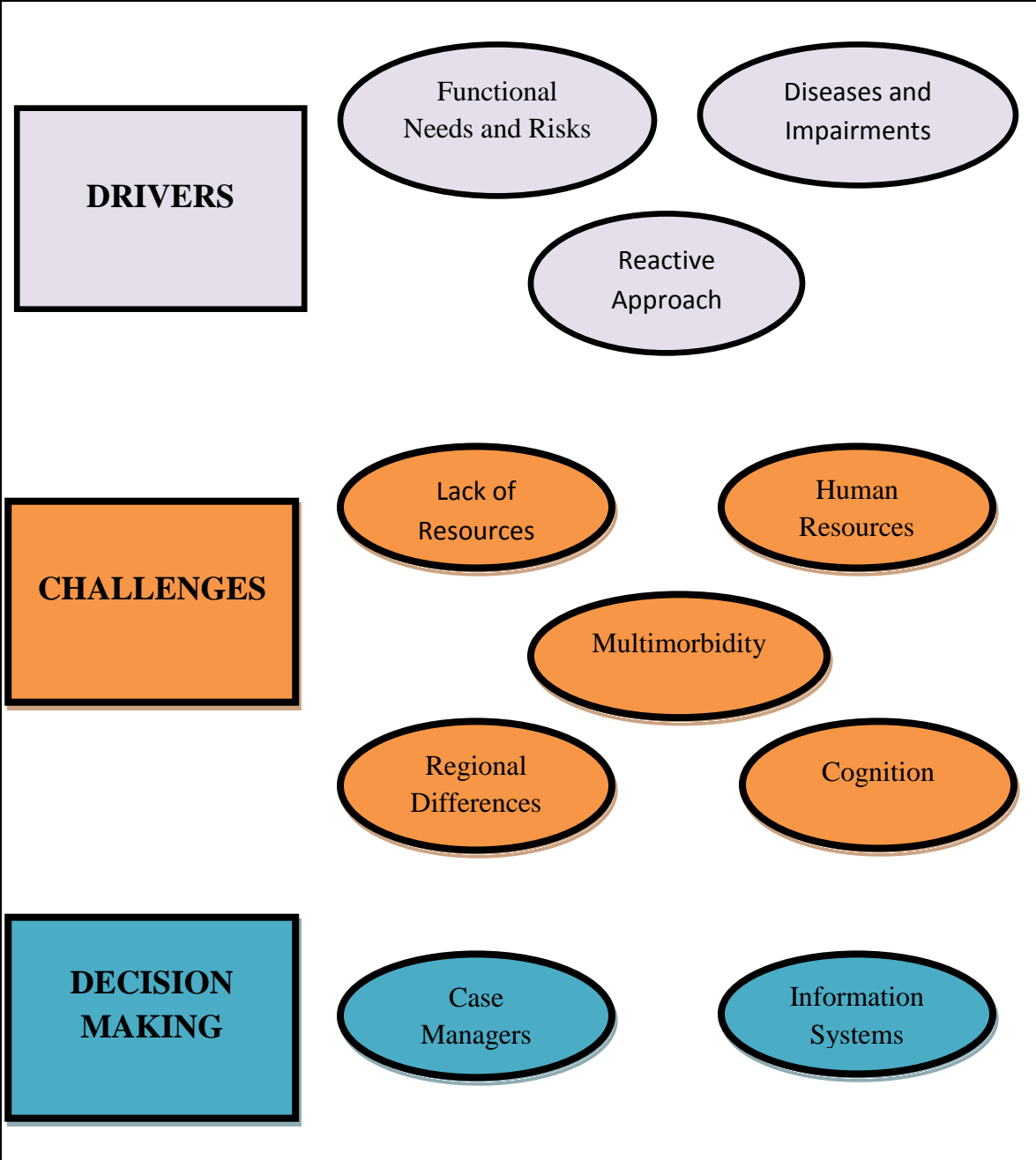
“I think that what I like about the – the RAI tool is that it hopefully will encourage a case manager to think through other options, but I think that clinicians can be biased by their training and by their historical practice. And it would be interesting to have a – some kind of review mechanism, some kind of a way of encouraging and helping case managers, as well as any other clinicians, think through other options for patients.” – Maria

“I think that for [decision support], the more specific the better because it helps to guide case managers especially if they don't have a therapy background.” – Anna

“I think any decision support tool to help the case managers is necessary, even in terms of just building consistency in our organization...to improve that consistency and frankly, overall reputation of CCAC, in terms of accessing service. Something that says you know this is evidence based and this is helping you to form those decisions.”-Tina

“We are also struggling with how do you identify who gets rehab because everyone has a different appreciation of rehab because not all the case managers are rehab professionals and even within rehab professionals it depends on what population you have worked with.” - Kim

**Figure 3.** Summary graphic of themes and subthemes





### 3.4 Discussion

Using data from semi-structured interviews with 10 key stakeholders, three key themes and 10 subthemes were found related to the provision of rehabilitation therapy services to older adults in the Ontario Home Care System. Although many of the ideas that came out through the qualitative research process were not entirely unfamiliar to the researcher, the results added greater depth and understanding of the problem domain. In addition to the results presented within this paper, the actual process of interviewing and connecting with key stakeholders from multiple perspectives was beneficial to the researcher.

From the first theme of Drivers of Rehabilitation Service provision, it was found that while the health profiles of older adults are complex and include a high prevalence of multimorbidity, decisions to provide OT and PT are generally based upon the client's functional needs. By focusing on functional needs, rehabilitation therapy services can be utilized in a way that is client centred rather than disease focused. However, this approach does not directly relate to the standard way that best practices and care pathways are developed; these approaches tend to be based on specific diagnoses (e.g., stroke, total knee replacement). Furthermore, despite the fact that multimorbidity is highly prevalent in home care clients, clients having multiple chronic diseases were not seen by these ten stakeholders as a direct driver of therapy service allocation. In other words, the fact that a client has multiple disease diagnoses does not directly influence the care planning decisions of case manager. Nevertheless, multimorbidity in geriatric home care clients is an important factor to consider when creating care plans and treatment strategies. Research has demonstrated that multimorbidity is related to increased length of stay in home care (Murtaugh et al.,

2009), and poorer outcomes in geriatric rehabilitation patients (Press, Grinshpun, Berzak, Friger & Clarfield, 2007). A better understanding of multimorbidity and patient outcomes is necessary for improving the quality and effective targeting of rehabilitation services in the Ontario Home Care System.

Each of the interviews included discussions that focused on client needs and common drivers of PT/OT service. However, the study participants seemed to have a limited understanding of system trends at a regional or provincial level. Most of the participants spoke of drivers based on their own clinical experiences. Therefore, it can be understood that there is a gap in understanding of the factors that tend to drive rehabilitation service provision across the provincial system. This type of information may be of potential use to those who aim to improve the overall system through policy development and regional/provincial strategies for the growing population of frail elderly.

From within the Challenges theme, by far the most salient subtheme was the fact that the Ontario Home Care System operates using a limited amount of resources, and this limited amount of resources directly impacts the provision of rehabilitation services to older adults. Therefore, although the demand for rehabilitation services is great, the home care system is unable to thoroughly address this need due to a lack of resources. Consequently, strategies and knowledge of how to make the system more effective and efficient will be increasingly important. It was also clearly noted that difficulties in access occur for remote or rural clients within the home care system. The challenges of providing home care have been discussed previously in the scientific literature (Kitchen, Williams, Pong, & Wilson, 2011; Forbes & Edge, 2009; Forbes & Janzen, 2004). Providing rehabilitation services for rural clients can be difficult due to transportation issues (travel time for PT and OT) as well

as a lack of available professionals living and working in their region. Unfortunately, this study did not include any interviews with stakeholders from the northern health regions (North West CCAC and North East CCAC) where these issues are magnified due to the size of the region and the larger proportion of remote and rural clients. Their insights into this issue would be important in terms of an understanding of the whole provincial system including strategies and practices that are taken to deal with the geographical challenges.

The finding that rehabilitation services are being used mostly in a reactive way was provocative. Traditionally, rehabilitation services in home care have the goal of improving or maintaining physical functioning, quality of life, and the overall independence of home care clients. However, the results of this study seem to indicate that rehabilitation services are primarily utilized for post-acute care and to avoid risk of additional health care system use. This finding is not entirely new as it coincides with results from other Ontario based research studies (Passalent, Landry, & Cott, 2010; Passalent, Landy, & Cott, 2009). These findings add to a growing body of literature that illustrate that people with chronic diseases have trouble accessing rehabilitation therapy services, despite client needs. While providing rehabilitation therapy services to individuals who suffer from chronic disease may appear too costly up front, there is great potential for these services to impact future health care use and indirect societal costs (dependency on social benefits, care giver time, loss of productivity). The results of this study also indicated that currently in the Ontario system, OT is primarily used for home safety assessments, and for home equipment purposes. This was surprising as the traditional role of an OT involves much more than environmental assessments and equipment.

The results of this study also indicated the increased complications of working with an older population. In terms of health characteristics, older adults are a heterogeneous population with a wide range of disease diagnoses, impairments, and needs. For rehabilitation services, some diagnoses and health issues have clear care paths that involve the provision of PT and OT. However, for complex frail elderly, no such care paths or evidence bases exist. This makes for an increasing number of home care clients who are complex and challenging to manage (Murtaugh et al., 2009). Additionally, cognitive impairment is often referred as a barrier for geriatric rehabilitation (Gruber-Baldini et al, 2003). However, within this study those who were interviewed did not explicitly see it as such. Cognitive decline tends to only impact decisions related to allocation if the impairment is severe, and if the client does not have care givers who can assist the client with the exercises. For the ten interview participants, the impact of cognitive decline on the provision of rehabilitation services was not a black and white issue. There are always nuances that are considered in the decision making process and having some cognitive decline was not thought of as a barrier for service allocation.

The final theme that was developed from the interview data was Decision Making. Within this theme, it was stated by a number of participants that the current CAPs developed within the RAI-HC were not suitable and were typically ignored by case managers due to their sensitivity. These CAPs were designed to indicate potential for benefitting from rehabilitation services. Unfortunately, virtually every individual who becomes a long-stay home care client could benefit from rehabilitation therapy due to the nature of the client population. Therefore, the too frequently triggered CAPs related to rehabilitation services are often ignored by case managers. One aspect of the home care system that should be

considered if these CAPs were to be improved is that home care does not operate in a vacuum and some clients who may benefit from receiving rehabilitation services could access and receive services from outside the home care system. Because of this, decision support systems for rehabilitation therapies services in home care would be improved if they focused on identifying specific populations that would benefit most from receiving rehabilitation therapy services within their home. For example, decision support systems could be developed to identify individuals who would have the most trouble accessing community based services (e.g., those who are home-bound or severely immobile, those who live in regions where PT is not available within the community). This type of decision support could also be developed to identify home care clients who could benefit from therapy services but are of able body to attend a clinic within their community. In this case, case managers would work towards assisting the client in accessing these community services. In Ontario, accessing OHIP covered community based rehabilitation therapy services may require a doctor's referral (Ontario Physiotherapy Association, 2012). If this is the case for a client, the role of a case manager may be to inform and educate the client about his/her rehabilitation therapy options within their community.

The results of this study also indicated that case managers could benefit from the development of new decision support algorithms that are tailored to specific rehabilitation therapy services. It was also indicated that any new decision support algorithms should be developed to give more than a simple yes/no response. For example, it was explicitly indicated that outcome measures that had more of a range would be useful in decision making. Furthermore, because of the fact that case managers have a variety of educational backgrounds, many of them do not have any direct experiences with rehabilitation services.

These case managers, as well as recently hired case managers, would benefit most from enhanced decision support systems related to rehabilitation.

In terms of the larger KDD project, this researcher found the qualitative process as a useful way to develop knowledge of the problem domain. The provincial home care system and the rehabilitation therapy services provided to older adults are multifaceted and puzzling to the uninitiated (complex clients within a complex system). Without an enhanced understanding of the complexities and the potential issues related to the problem domain, developing potentially useful quantitative analyses of provincial data repository would be challenging. The use of qualitative methods to develop knowledge of the problem domain in KDD project is novel, and no examples of this type of approach were found within the literature. As the development of domain knowledge and problem understanding is essential for accurate and useful development of knowledge from large databases, qualitative research techniques should become important tools for future researchers who hope to use “big data” in their work. This study will be used to inform variable selection for descriptive analyses and will assist in the creation and development of models in Phase 4. More specifically, modeling procedures will include cluster analyses to develop an understanding of the older population of rehabilitation users by identifying the patterns of characteristics that develop within the wide variety of problems that older clients experience as discussed in the interviews. Secondly, predictive models will be created to develop an understanding of the main drivers of rehabilitation therapy service provision in the Ontario Home Care System. It was found within the interviews that OT and PT are utilized in significantly different ways; therefore separate predictive models will be created for each type of therapy. These

predictive models will also have to consider the regional differences that were found within Phase 1 activities.

In addition to enhancing ‘business understanding’ of the problem domain, the qualitative approach within the KDD process also allows for the researcher to make connections directly with a number of stakeholders from within the Ontario Home Care System. These connections will be used as potential avenues for knowledge translation activities. Typically in academia, knowledge translation takes place through writing scientific articles and presenting at conferences. However, now that a number of stakeholders from varying perspectives have participated in the research project, it is anticipated that these individuals might be more likely to review the results of the study, share it with the colleagues, and incorporate some of the ideas into their practice or policies.

The limitations of this study include the small sample size and the lack of additional researchers in the analysis of the data. Although the sample represented three different perspectives and multiple health regions in southern Ontario, the study would have benefitted from sampling stakeholders from other areas of the province including the two northern CCACs. Although it was a limitation to have only one individual perform the analyses, the main purpose of this qualitative study was to build a ‘business understanding’ of the problem domain within a KDD project. For the KDD project, the individual who performed these interviews and analyzed the transcripts will also be conducting the quantitative analyses of the large provincial database.

A further limitation of the study was the lack of clarity regarding key terms in rehabilitation, including ‘function’ and ‘impairment’. The World Health Organization uses the International Classification of Functioning, Disability, and Health, known more

commonly as the ICF, as a framework for measuring health and disability. Within the ICF, body function is defined as the physiological and psychological functions of body systems, where impairment is defined as problems in body function as a significant deviation or loss. Many of the interviews discussed home care client characteristics as ‘functional needs’ and ADL impairments, where it may have been more appropriate to use ICF terminology. The ICF framework is based on a bio-psycho-social model of functioning and disability, in which functioning and disability are multi-dimensional phenomena experienced at the level of the body, the person, and society (United Nations Economic and Social Commission for Asia and the Pacific, 2012). This framework also incorporates environmental factors that impact a person’s functioning. Discussion of body function and impairment in older home care clients using the ICF framework may have led to development further clarity of how these client characteristics are related to OT and PT service provision.

A final limitation revolves around the discussion of the Clinical Assessment Protocols (CAPs) and the current decision support mechanisms available within the RAI-HC information system. The discussion did not fully reveal the level of understanding and the amount of experience that the interviewees had of the CAP system and other decision support mechanisms found within the RAI-HC. For example, it was not clear which version of the CAPs that individuals were talking about in the interviews (a newer version of RAI-HC CAPs were released in 2007 and are still being implemented across the province). Further clarification of these details would have been informative for quantitative activities performed during Phase 2-4, as well for possible future research work in the development of decision support services for rehabilitation therapy services for the Ontario Home Care System.



Overall, this study was a beneficial activity in terms of building ‘business understanding’ and the results will be applied in a KDD project with the goal of informing and enhancing quantitative analyses of a large provincial database. Quantitative analyses will include examination of the heterogeneity found with the rehabilitation service user population; an examination of the drivers of service provision; and a descriptive study examining population characteristics and rehabilitation therapy service provision. Within the Ontario Home Care System, this author believes that there is great room for improvement on the use of rehabilitation services for older adults. Although the past practices were seen as reactive, the system can be improved with more appropriate targeting of the limited resources. To achieve this, future work should focus on the development of an evidence base and the creation of novel decision support algorithms for the growing complex frail older adult population. Many challenges in providing rehabilitation therapy services to older home care clients will likely persist over time, nonetheless it is important to work towards improving the system.

## **4.0 REHABILITATION THERAPY SERVICE USE AND POPULATION CHARACTERISTICS OF OLDER LONG-STAY HOME CARE CLIENTS IN ONTARIO (2005-2010)**

### **Overview**

#### **Background**

The objective of this descriptive study is to examine rehabilitation therapy provision and population characteristics of older long-stay home care clients in Ontario using a provincial data repository. The rehabilitation therapy services that will be focused upon are occupational therapy and physiotherapy. This current study follows a qualitative study that examined this topic through a series of semi-structured interviews. Findings from the qualitative study were used to inform and guide variable selection. This study also precedes a series of quantitative analyses and results will inform quantitative projects that will also utilize RAI-HC data. The entire thesis project is conceptually guided by the Andersen-Newman Framework for Health Services Research.

#### **Methods**

The data that will be used for this study are the initial RAI-HC assessment of every older ( $\geq 65$ ) long-stay home care client (in system greater than 60 days) who entered the system between 2005 and 2010, inclusive (N = 299 262). Each assessment has been linked to service use information. For each assessment, the use of OT and PT in the following 3 months after the initial assessment will be examined. Client characteristics of the following groups will be examined using data visualizations and descriptive statistics: OT-only, PT-only, Both OT and PT, and None.

#### **Results**

For the time period included in the data, 38% of older home care clients received rehabilitation services after entering the home care system as a long-stay client. By systematically reviewing population characteristics using the Andersen and Newman Framework, a number of insights into the data were developed. Findings include large variation in rehabilitation provision across the province's health regions, decreased provision to cognitively impaired clients, and a wide assortment of need factors.

#### **Conclusions**

After reviewing the characteristics of the home care population and their use of rehabilitation services, it is clear that home care clients form a large, complex and heterogeneous population with a wide range of disease diagnoses, physical impairments and health care needs. Due to the increasing size of Ontario over-65 population, the effectiveness and efficiency of rehabilitation services in home care are important. Due to a perceived lack of information related to the provision of rehabilitation therapy services across the province, there is a substantial room to develop understanding using the routinely collected data within the system. This current study and the following studies within this dissertation will aim to improve knowledge of this problem domain.

## 4.1 Introduction

In Ontario, the home care system provides a wide assortment of services to clients living in their homes within their communities. The majority of Ontario home care clients are older (56% in 2009/10; OHCA) and home health care services provided by the province play an important role aging in place initiatives (William et al., 2009), chronic disease management, and strategies related to primary care (Canadian Home Care Association, 2008). In addition to support services (e.g., home making.) and nursing, the Ontario Home Care System also provides rehabilitation therapy services such as occupational therapy (OT) and physiotherapy (PT). Despite evidence of the feasibility and effectiveness of these rehabilitation services for older adults in home based settings (Gill et al., 2002; Kuisma, 2002; Crotty, Whitehead, Miller, & Gray, 2003; Gitlin, Hauck, Winter, Dennis, & Schulz, 2006; Gitlin et al., 2006; Giusti et al., 2006; Stolee, Lim, Wilson, & Glenney, 2011), many do not receive these services despite actual and perceived needs (Borrie, Stolee, Knoefel, Wells, & Seabrook, 2001; Jaglal et al., 2003; Poss et al., 2005).

In order to develop a better understanding of rehabilitation therapy services for older adults in home care, a Knowledge Discovery in Databases project was designed to systematically examine a large provincial data repository of assessment data. Knowledge Discovery in Databases (KDD) is “the nontrivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data” (Fayyad, Piatetsky-Shapiro, and Smyth, 1996). This type of approach typically takes place on large volumes of electronic data and through a process that involves a series of steps that are interactive and iterative. Steps in the KDD process include developing domain knowledge, selecting and cleaning data, data mining, and knowledge deployment. This process has been standardized

by numerous groups and the most popular process model to date has been the Cross-Industry Standard Process for Data Mining (CRISP-DM; Kurgan & Musilek, 2006). The CRISP-DM (Chapman et al., 2000) consists of six phases.

- 1) Business Understanding,
- 2) Data Understanding,
- 3) Data Preparation,
- 4) Modeling,
- 5) Evaluation,
- 6) Deployment.

This descriptive study will serve as a report for Phase 2, “Data Understanding”. Key variables will be examined including PT provision, OT provision, predisposing factors, enabling factors, and need factors. This study builds upon a qualitative study performed in Phase 1 of the CRISP-DM and will precede modeling procedures in Phase 4. Findings from the qualitative study in Phase 1 influenced the variables selected for examination within this chapter as well as the interpretation of the findings. Findings from these descriptive analyses will influence predictive modeling through the preparation of the data prior to modeling, predictor variable selection, and interpretation of results.

### **Study Purpose**

The focus of this chapter is on exploring and describing data from older clients ( $\geq 65$ ) within the Ontario Home Care System. This chapter will form a key component of the data understanding phase (Phase 2) of a Knowledge Discovery in Databases (KDD) project. The main purpose of this exploratory data analysis is to use descriptive statistics and data visualizations to summarize the key attributes and main characteristics of older home care clients and their use of rehabilitation therapy services prior to creating data mining and statistical models. Data for this study will be drawn from a provincial data repository of

RAI-HC assessments that has been linked to rehabilitation therapy service utilization information. This study will prepare the analyst for Phase 3 of the CRISP-DM, where the same RAI-HC data will be prepared for modeling procedures. Results of Phase 2 will also influence variable selection and choice of modeling techniques within Phase 4.

## **4.2 Methods**

### **Conceptual Framework**

The Andersen and Newman Behavioural Model of Health Service Use has been the primary conceptual framework used to organize health services utilization research for the last forty years. Numerous research projects that aimed to understand home care utilization by the elderly have applied the Andersen-Newman framework (Kempen & Suurmeijer, 1991; Kadushin, 2004; Algera, Francke, Kerkstra, & Van Der Zee, 2004). The basic structure of the model organizes the determinants of health service use into societal determinants, system determinants, and population characteristics with the overall aim of discovering conditions that either facilitate or impede health care service utilization (Andersen & Newman, 1973). This model organizes the population characteristics into predisposing factors, enabling factors, and need factors. Predisposing factors refer to the predisposition of an individual to use services; these include variables such as age, gender, language, and marital status. Enabling characteristics are variables that reflect the ability of individuals to obtain services. These can include factors such as availability of services, psychological characteristics, and personal/family relationships. Need factors, which often form the most immediate cause of health service usage, refer to an individual's level of

illness and disability. Within the Andersen and Newman framework, the dependent variables are operationalized as health care services use and perceived health practices.

For this current descriptive study, the results will be organized into the following four categories: (1) Service utilization; (2) Predisposing Factors; (3) Enabling Factors; (4) Need Factors. Need factors will be further broken into sections containing outcome scales, Clinical Assessment Protocols (CAPs), activities of daily living (ADLs), instrumental activities of daily living (IADLs), and disease diagnoses.

## **Sample**

For this study, the data will consist of the initial RAI-HC assessment for every long-stay client over the age of 65 entering the Ontario home care system between 2005 and 2010 (N = 299 262). The RAI-HC assessment system has been mandated for use for all clients expected to use home care services for more than 60 days, which therefore provides Ontario census-level data on long-stay home care clients. The RAI-HC is one of a suite of standardized assessment tools (Gray et al., 2009; Hirdes et al., 2008) developed by the international interRAI consortium and contains a wide variety of assessment items including demographic information, cognition, physical functioning, disease diagnoses, nutrition/hydration status, environmental assessment, and service utilization. Collected by frontline workers using data entry software, the assessment system has checks during data input that constrain item entries as non-missing, within correct ranges, and includes logical checks. All RAI-HC assessments that were performed in hospital for long-term-care home placements were removed. The RAI-HC is considered to be reliable and valid, with the

individual items having been tested for their inter-rater and test-retest reliability (Morris et al., 1997; Landi et al., 2000; Hirdes et al., 2008; Poss et al., 2008).

## **Measures**

The selection of variables in this study was guided by the qualitative study in Phase 1 of the CRISP-DM process. All variables selected for analysis will be organized using the Andersen and Newman framework. Figure 4 contains a chart that highlights the Andersen and Newman groupings and the variables found within each grouping.

### Service Utilization

Each RAI-HC assessment has been linked to OT and PT service utilization data from the Ontario Home Care Administrative System (OHCAS). All OT and PT service visits were provided through the CCACs were recorded in this system. For these analyses, the window examined was the provision of any OT or PT within 90 days of the initial RAI-HC assessment. This window of service provision was chosen to be an adequate amount time to capture service use in relation to the RAI-HC assessment information.

### Predisposing Factors

Predisposing factors are the socio-cultural characteristics of the clients that existed prior to their use of home care services. The predisposing factors that are recorded within the RAI-HC and included in these analyses include sex, age, language, and marital status.

### Enabling Factors

Enabling factors are characteristics that can facilitate or inhibit service utilization. The enabling factors that are recorded within the RAI-HC assessment include location within province, caregiver variables, education, and home bound status. Location is

indicated by the Community Care Access Centre membership. Caregiver variables include caregiver's inability to continue, and caregiver burden (caregiver expresses feelings of distress, anger, or depression). Home bound status can be determined by the RAI-HC item that measures the amount of time that the client spends at home vs. out of their residence.

### Need Factors

Need factors are often considered the most immediate cause of the health service use. As the RAI-HC is a comprehensive assessment, it contains a wide variety of variables that can be considered as need factors. Although there is a wide range of individual items that could be examined, this descriptive study focused in on outcome scales, Clinical Assessment Protocols, individual ADL/IADL impairments, and disease diagnoses.

A number of standard interRAI outcome scales have been developed, all of which are derived from the individual RAI-HC assessment items. These scales include the Cognitive Performance Scale (Morris, et al., 1994), the MDS Pain Scale (Fries, et al., 2001), a measure of health instability called the MDS-CHESS (Changes in Health, End-stage disease, and Symptoms and Signs; Hirdes, et al., 2003), a hierarchical measure of activities of daily living (Morris, et al., 1999) and a instrumental activities of daily living capacity (Morris, Carpenter, Berg, & Jones, 2000). These scales can be used to measure and communicate the status and outcomes of home care clients.

Also found within the RAI-HC are Clinical Assessment Protocols (CAPs). CAPs are designed to trigger after the completion of the assessment in order to flag key issues for follow up. The intention of CAPs is to assist the assessor in identifying problems and support decision-making in care planning. The goals of care vary from one CAP to the next, however, they include goals such as the possibility of resolving the problem, reducing the



risk of decline, or increasing the potential for improvement. interRAI's CAPs within the RAI-HC cover problems in four broad areas:

1. Functional performance
2. Cognition and mental health
3. Social Life
4. Clinical issues

For this project, the main of interest is in the CAPs within the Functional Performance Domain. These include Physical Activities Promotion (cPACTIV), Instrumental Activities of Daily Living (cIADL), Activities of Daily Living (cADL), Home Environment Optimization (cENVIR), and Institutional Risk (cRISK). Other CAPs of interest with regards to OT and PT are Falls (cFALLS) and Pain (cPAIN) within the Clinical Issues Domain. More detailed information on these CAPs can be found in a published manual (Morris et al. 2007).

For the domain of ADL and IADL impairments, seventeen individual items are recorded during the RAI-HC assessment on specific types of impairment. These include ten ADL items and seven IADL items. For this study, these items have been dichotomized. For the ADL functioning, items have been split between independent/some supervision vs. limited assistance to total dependence (0-2 vs. 3+). Similarly for the IADL items, items have been split between independent vs. some help performed by others (0 vs. 1+).

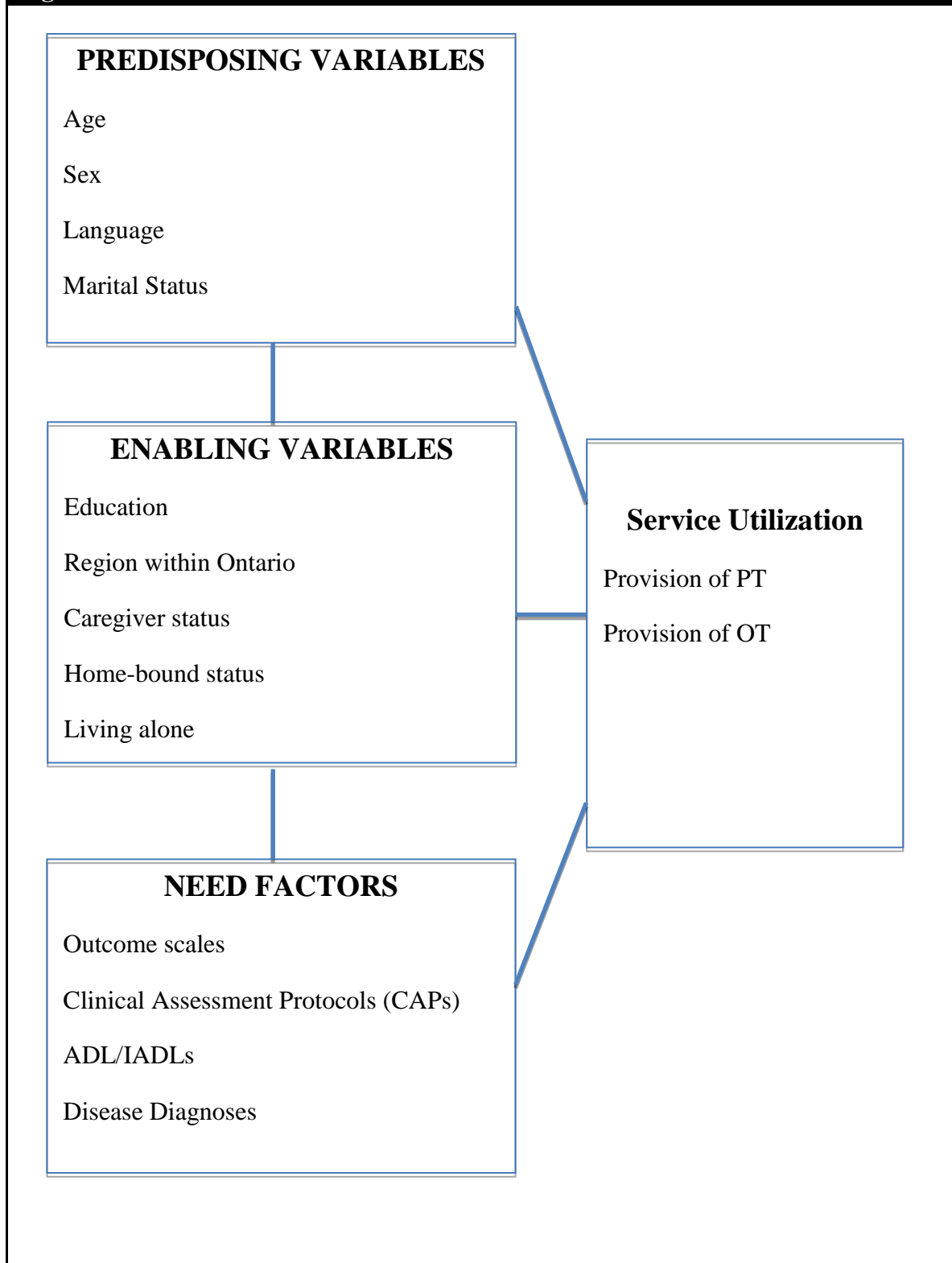
The third category of need factors that were chosen for examination is disease diagnoses. These items are collected in the RAI-HC and are included if a doctor has indicated that this disease is present and affects the client's status, requires treatment, or symptom management. In addition to single disease diagnoses, a multimorbidity count was also created to indicate the number of concurrent chronic diseases each client has. For this count,

the presence of any of the diseases found in Table 8 was added up for a final multimorbidity score.

## **Analyses**

In order to enhance understanding of rehabilitation therapy services and the population who are provided with these services, data tables and visualizations of key characteristics were created. For many of the analyses, the population was grouped into the following categories based upon the service utilization records: Receiving PT-only, receiving OT-only, and receiving both OT and PT. Significance testing was not performed between groups in this study due to the size of the data (N= 298 262). Because the sample size is so large, small differences between groups can be significant even if it has little or no clinical meaning (Cohen, 2011). Therefore, general trends were identified rather than statistically significant differences. Correlations for outcome scales across the whole population were also examined and averages and standard deviations for continuous variables (outcome scales, age) were calculated.

**Figure 4. Variables Included Based on the Andersen-Newman Model**

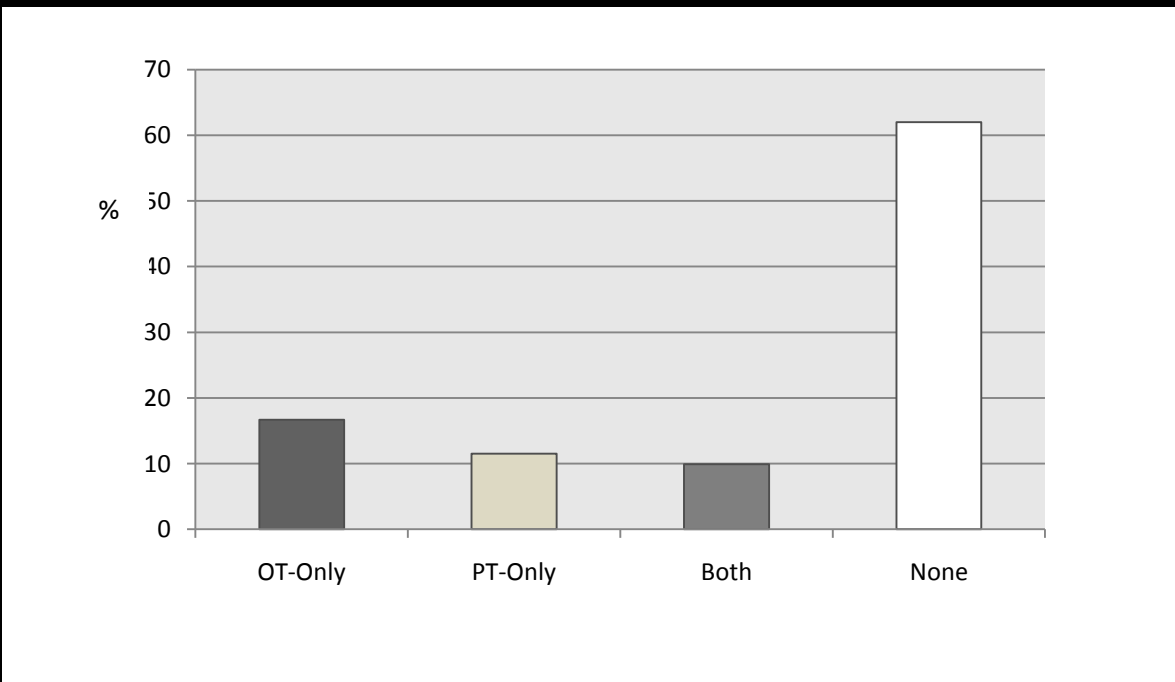


## 4.2 Results

### Rehabilitation Service Use

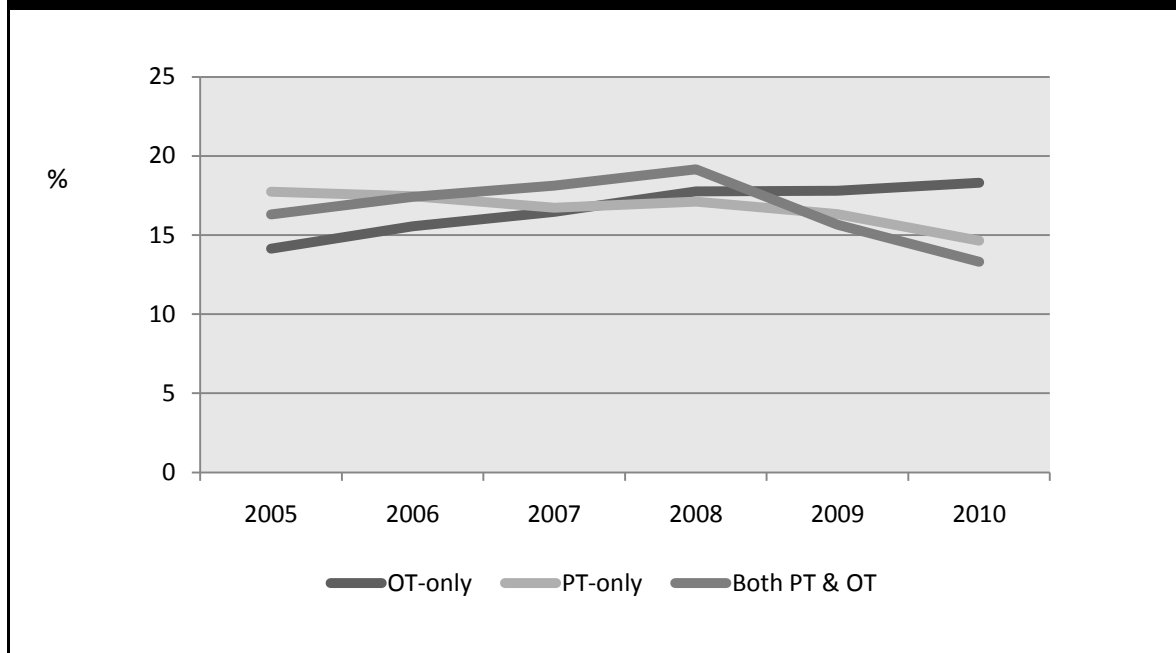
Figure 5 illustrates the proportion of clients who receive rehabilitation services within three months of their initial RAI-HC assessment when entering the home care system. Of all long-stay clients who entered the home care system between 2005 and 2010, 26.5% received OT services within three months of their initial RAI-HC assessment. In terms of PT services, 21.4% of all long-stay clients received services after their initial assessment. No rehabilitation services were provided to 62% of these clients while 9.9% received both OT and PT. This information does not capture any older clients who are classified as short stay clients (expected to be in home care less than 60 days) or rehabilitation therapy services provided prior to the RAI-HC assessment.

**Figure 5.** Proportion of all older clients receiving rehabilitation therapy services within three months of their initial assessment



In terms of the trends over time, the proportion of older long-stay home care clients that receive OT-only steadily increases, while the rate of PT-only decreases over the same time period. For receiving both OT and PT, 2009/2010 saw a sharp decline. This information is presented in Figure 6.

**Figure 6.** Proportion of clients over the age of 65 receiving PT, OT, or both, by year



### Predisposing Variables

Table 2 contains information on the sex, age, language, and marital status distributions for the overall population, OT-Only, PT-Only, Both, and no services. There are no major differences between the sexes as differences between males and females are small across all user groups. When examining age, 67.1% of rehabilitation services are provided to clients aged between 75 and 89. Looking across the age groups, no clear trend appears for OT use. For PT-only, there appears to be a slight decrease in provision rates for clients over the age of 90. The average age of the overall population and the OT-Only group was 81.1 years (Overall SD = 7.4; OT-Only SD = 7.3). The average age of PT-Only was slightly

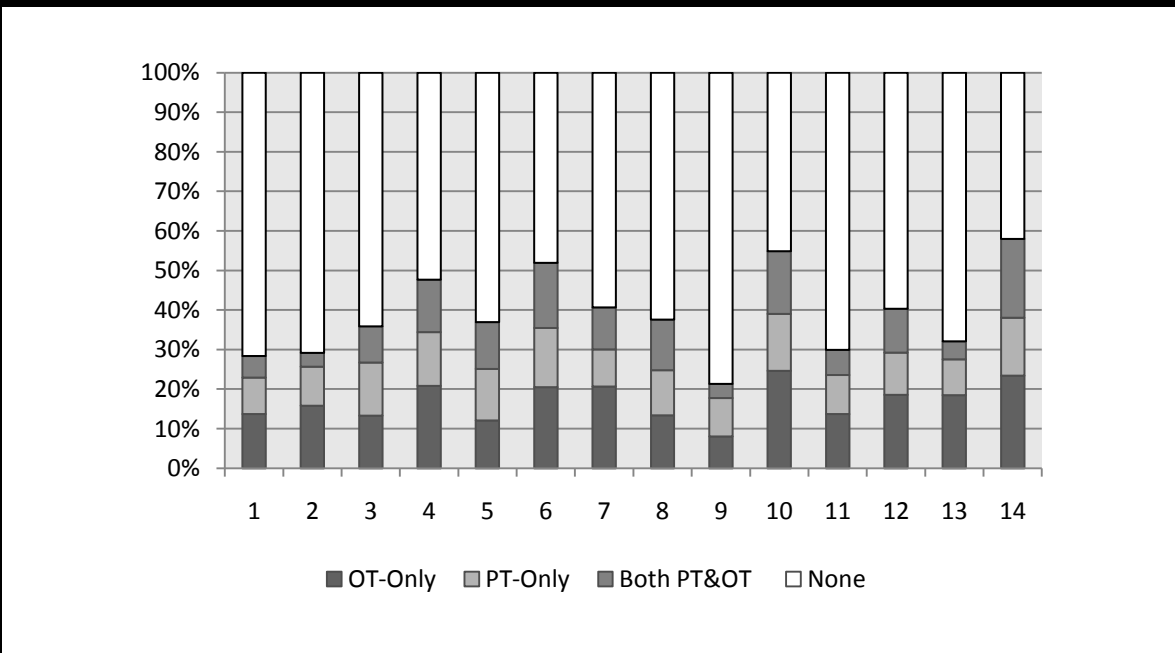
younger at 80.8 (SD = 7.1). The average age of clients that received both rehabilitation therapy services was the youngest at 80.3 (SD = 7.1). Findings from the remaining two predisposing characteristics of marital status and language can be found within Table 5.

<b>Table 5. Percentage of Clients with Predisposing Characteristics by Rehab User Group</b>					
<b>Variables</b>	<b>Overall %</b>	<b>Receive OT-Only %</b>	<b>Receive PT-Only %</b>	<b>Receive Both %</b>	<b>Receive None %</b>
<b><u>Sex</u></b>					
Male	37.5	16.7	11.1	10.5	61.7
Female	62.5	16.6	11.7	9.5	62.1
<b><u>Age Groups</u></b>					
65-69	8.6	16.4	11.2	10.8	61.7
70-74	13.1	16.9	12.0	11.1	60.1
75-79	20.4	17.0	12.1	10.6	60.3
80-84	26.0	16.8	11.9	10.3	61.0
85-89	20.7	16.4	11.2	8.8	63.5
90-94	9.0	16.0	10.1	7.5	66.4
95-99	2.0	16.3	8.6	6.9	68.3
100+	0.3	17.8	6.7	6.7	68.9
<b><u>Language</u></b>					
English	80.1	16.5	11.7	10.0	61.8
French	2.9	15.6	11.0	8.1	65.4
<b><u>Marital Status</u></b>					
Never married	4.2	16.4	10.1	8.2	65.3
Married	42.1	16.3	12.3	11.0	60.4
Widowed	46.9	16.8	11.1	9.0	63.1
Separated	1.6	19.3	9.1	8.8	62.8
Divorced	4.2	18.5	10.4	9.7	61.4

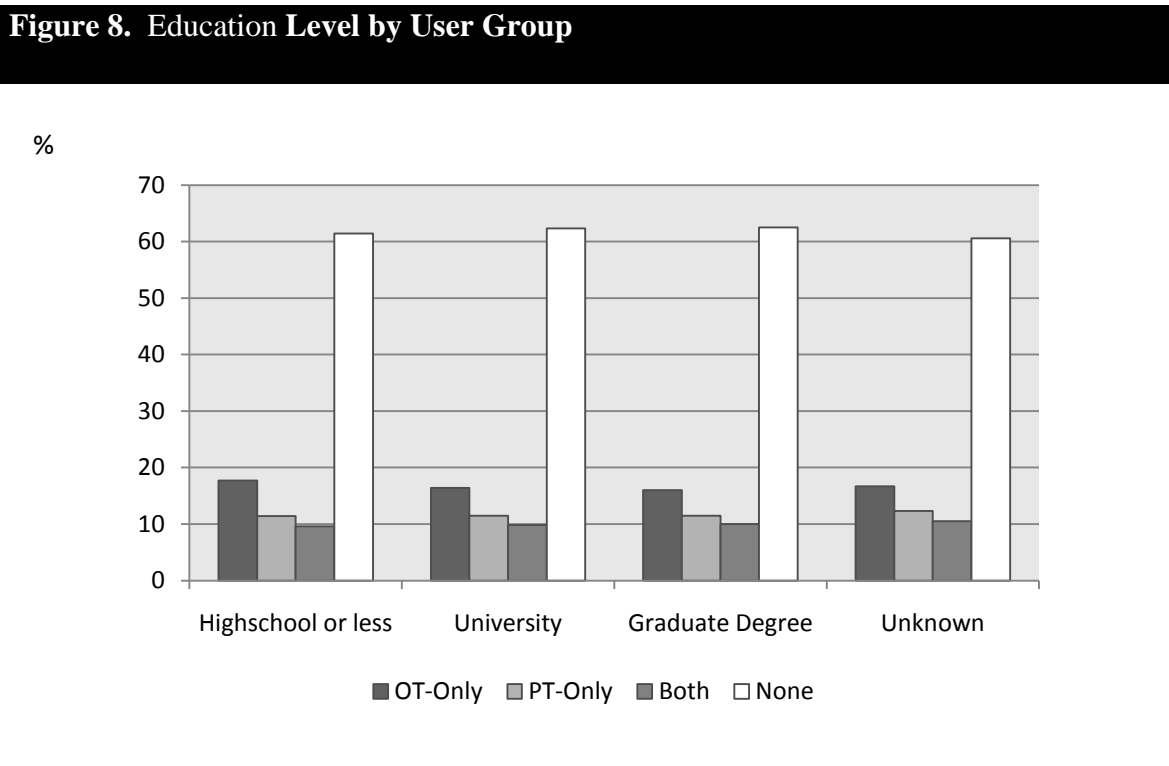
## Enabling Factors

Five enabling factors were examined: region of residence, education level, caregiver status, home-bound status, and living alone. A great amount of variation can be found across the 14 CCACs in Ontario. Proportions receiving any rehabilitation therapy services ranged from 20% to close to 60%. Much of this variation across health region is caused by differences in the provision of OT with an approximately 15% difference from the lowest rate (CCAC 8 = 8.1%) to the highest (CCAC 14 = 23.5%). For PT, the range is closer to 5% (CCAC 13 = 9.1%; CCAC 14 = 14.6). The provision of both OT and PT, there is also a wide range of differences: CCAC 2 provided 3.5% of their older clients with both services while CCAC 14 provided both services to 19.9% of their older clients. Further details regarding regional differences can be found in Figure 7.

**Figure 7.** Proportion of clients over the age of 65 receiving PT, OT, both services or none, by CCAC



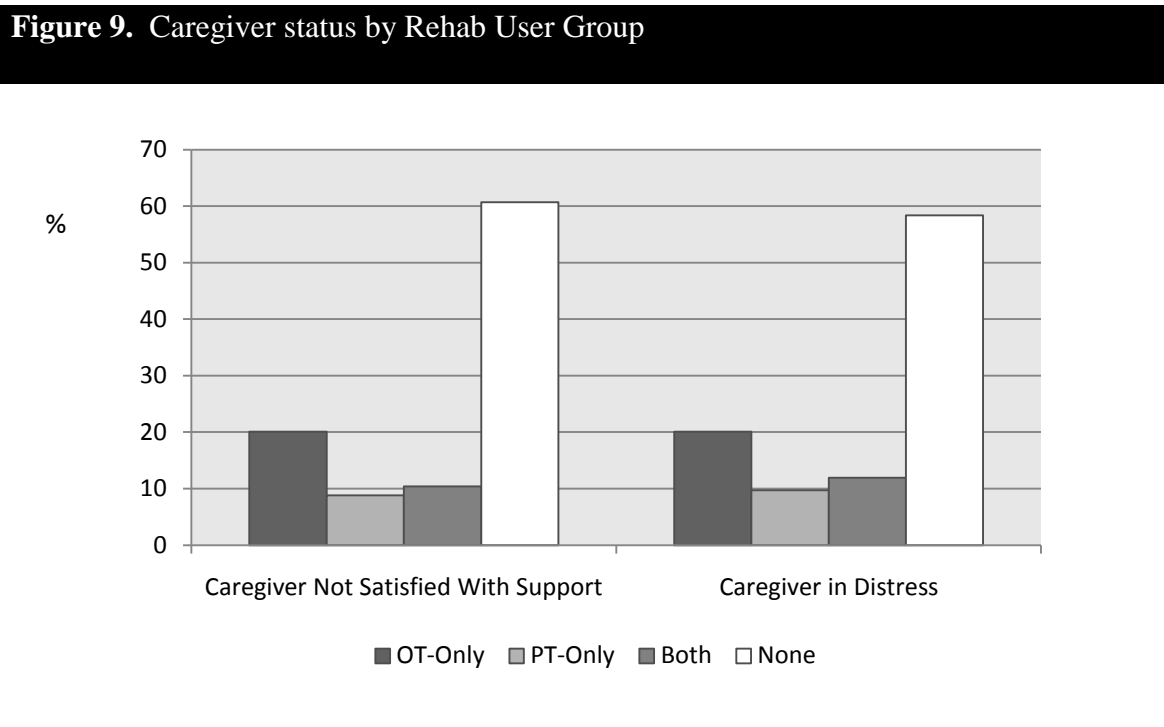
The majority of rehabilitation service users have an education level of a high school degree or less. Figure 8 examines the proportion of service provision by education level. This figure illustrates that there is no well-defined trend for education status. This may be due to the unknown category where 8% of clients do not have their education level recorded.



For clients who lived alone (found in item CC6 in the RAI-HC), 17.93% received only OT, 11.4% receive only PT, and 9.2% of clients who received both services. In terms of caregiver status, 20.0% of clients with caregivers who were not satisfied with the support that they were receiving were provided with OT only. Less than half as many of these clients received PT-only (8.8%), while 10.4% of these clients received both services. Similarly, 20.0% of clients with caregivers who were in distress received OT-only, 9.7%



received PT-only, and 11.9% received both services. Caregiver information for the three groups can be found in Figure 9.



### Need Factors

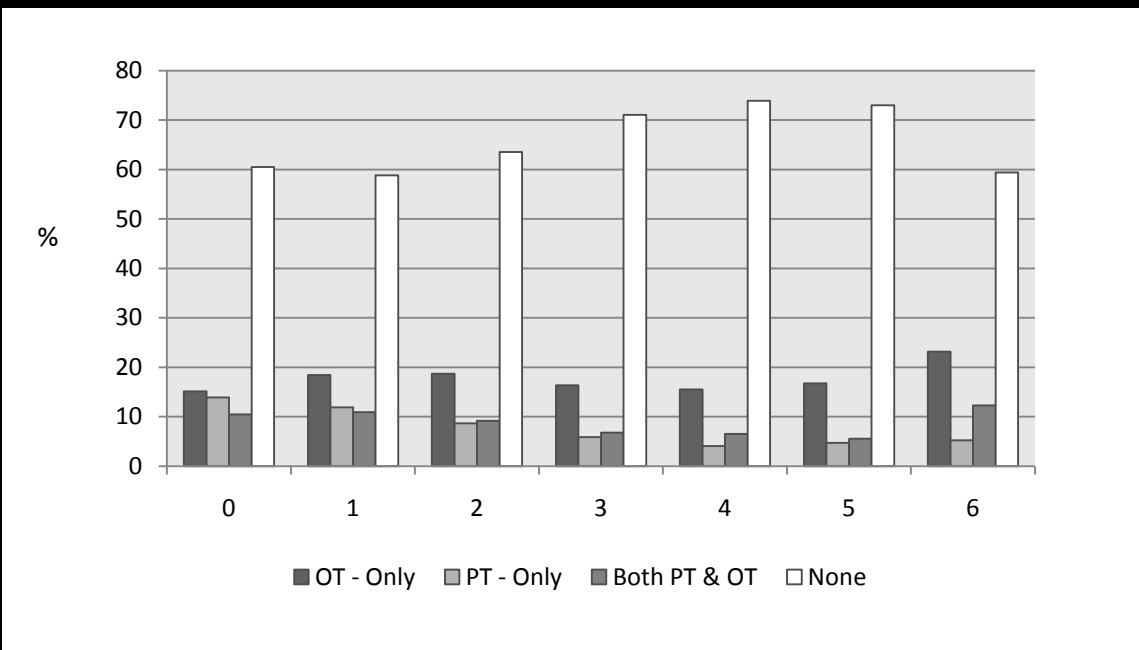
The RAI-HC contains an abundance of information on the need factors of home care clients. In order to focus this section on the most essential client characteristics, this section will review some of the interRAI outcome scales, CAPs relevant to rehabilitation therapies, the ADL and IADL impairments, and disease diagnoses. Table 6 contains the mean and standard deviation for a number of outcome scales found within the RAI-HC information system. This table stratifies the means by the receipt status of each of the clients: OT-ONLY, PT-ONLY, BOTH, and NONE.

**Table 6.** Mean and Standard Deviation (SD) for the Three User Groups

Scale	OT-ONLY		PT-ONLY		BOTH		NONE	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<b>Cognitive Performance Scale</b>	1.07	1.22	1.01	1.55	0.87	1.11	1.05	1.26
<b>ADL Hierarchy</b>	0.72	1.24	0.65	1.14	0.99	1.41	0.56	1.10
<b>IADL Performance</b>	3.87	1.70	3.86	1.62	4.14	1.51	3.59	1.88
<b>PAIN</b>	1.26	1.09	1.49	1.05	1.50	1.08	1.12	1.06
<b>CHESS</b>	1.49	1.09	1.43	1.01	1.61	1.01	1.16	1.06

Figures 10 through 14 illustrate the proportion of clients who receive rehabilitation therapy services by client scores in five of the interRAI outcome scales. For the Cognitive Performance Scale (CPS; Figure 1), scores range from 0 (intact) to 6 (severe impairment). For PT, the proportion of those receiving services diminishes as CPS scores increase. For OT, those with the most impairment are most likely to receive services. For clients who receive both of the services, individuals with a score of 6 are most likely to receive the two services combined.

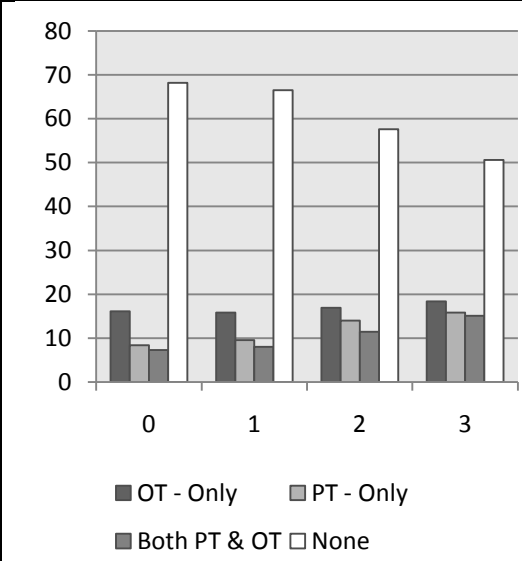
**Figure 10. Cognitive Performance Scale by Rehabilitation Service User Group**



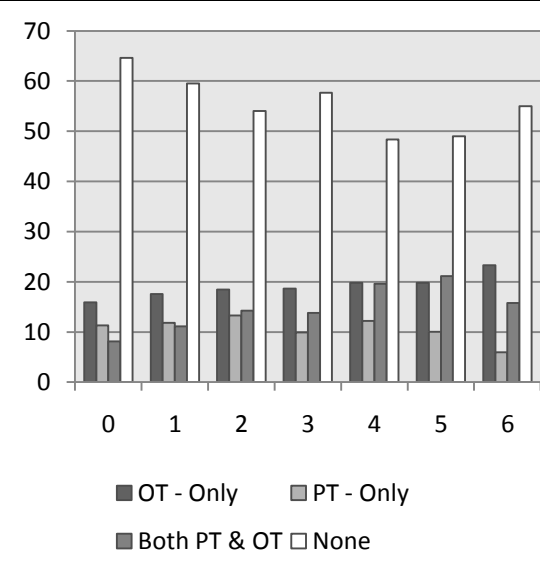
For the Pain Scale, the proportion of those receiving rehabilitation services increases with increases in the scale (0 = no pain, 1 = less than daily, 2 = mild/moderate, 3=severe).

Figure 12 examines the ADL hierarchy scale by the three groupings. The figure illustrates that as ADL impairment increases, so does the proportion who receives OT services. For PT services, there is no clear trend and the peak amount of service is at the level of 2. For the IADL capacity scale, OT services only peak when the scale is equal to 3 and then level off. Similar trends are found for both PT and the receipt of both rehabilitation therapy services. The next outcome measure explored was the CHES, which was designed to identify clients at risk of serious decline and can be used to identify clients whose health is unstable. For this scale, the clearest trend was again related to OT and it demonstrates that as CHES scores increase, so does the provision of OT services.

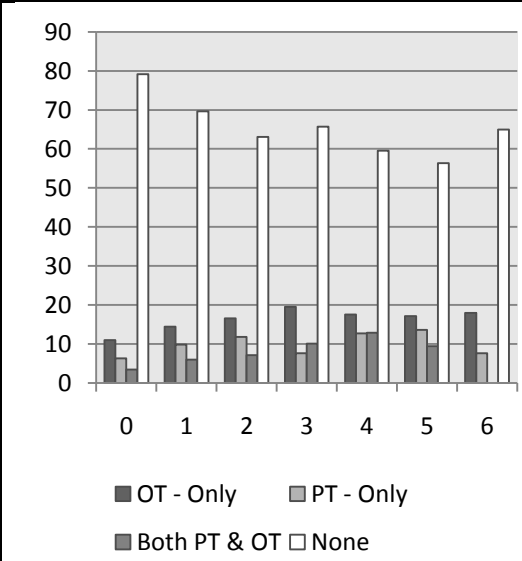
**Figure 11. Pain Scale**



**Figure 12. ADL Hierarchy Scale**



**Figure 13. IADL Capacity Scale**



**Figure 14. CHES Scale**

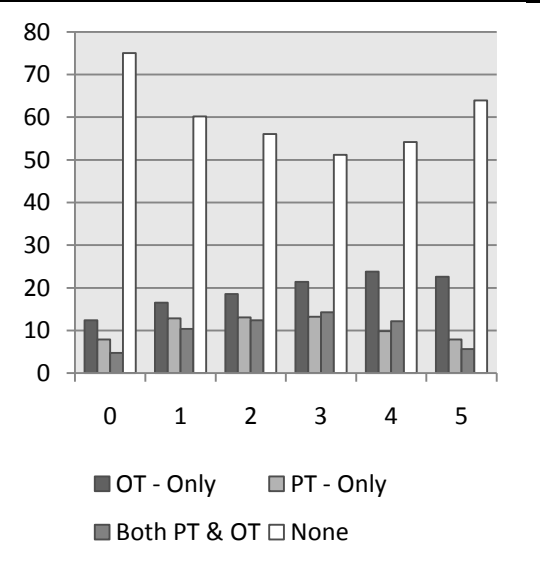
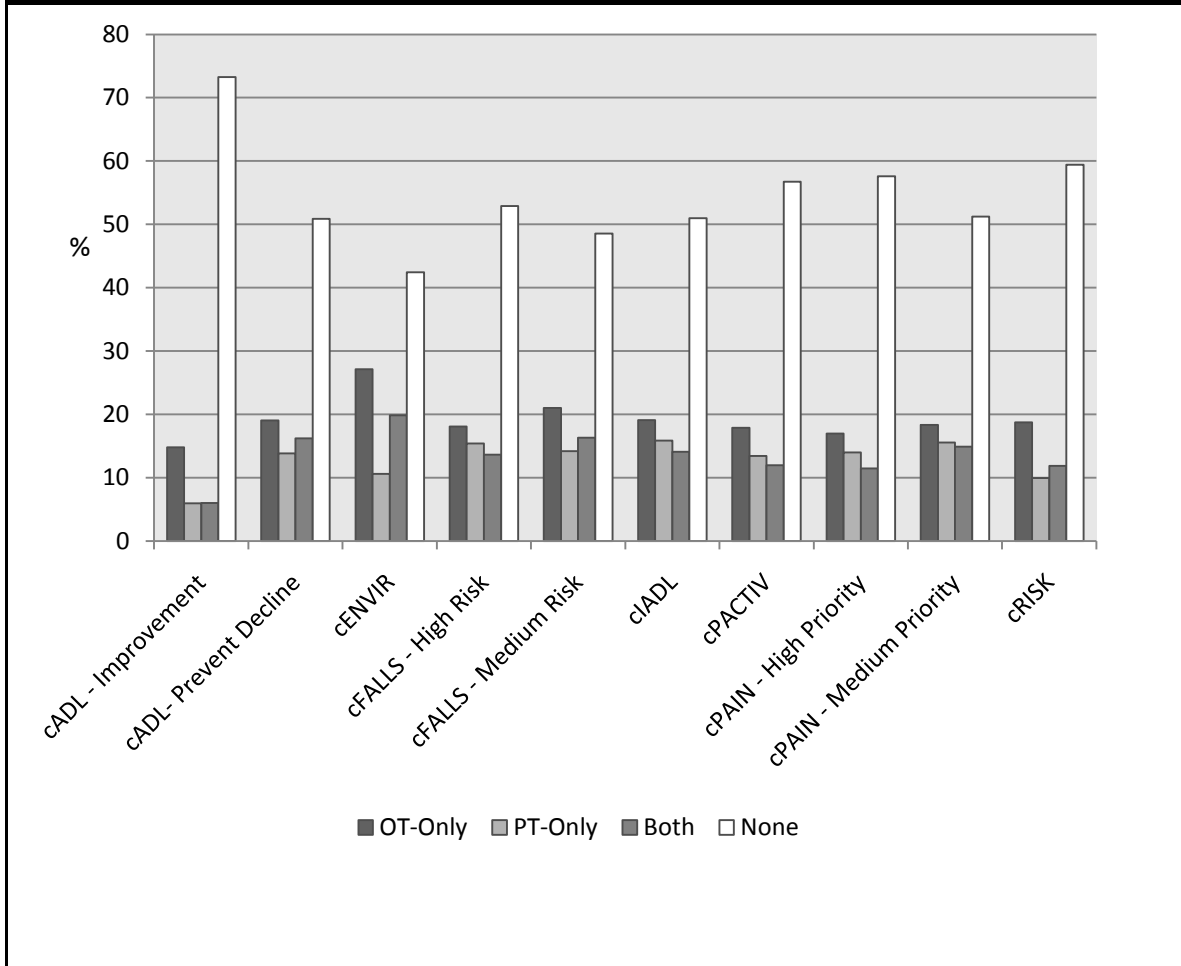


Table 7 and Figure 15 display the findings related to the seven CAPs that are related to rehabilitation therapy provision: cADL, cCARDIO, cENVIR, cFALLS, cIADL, cPACTIV, cPAIN, and cRISK. Table 7 indicates the rates at which these CAPs are triggered across all home care clients. Figure 15 illustrates the proportion of clients who receive rehabilitation services after triggering each CAP. For those that trigger the Environment CAP, more than 25% receive OT services within the three months after the assessment. Those who triggered the Falls CAP at the medium risk level were the second highest in terms OT receipt. Across the majority of the CAPs, 10-15% of those who triggered received PT services only. The one exception to that finding was that for those who triggered the ADL cap for improvement. For these individuals that triggered the ADL cap for improvement, only 6% received physiotherapy services.

**Table 7. Proportion of clients who trigger CAPs.**

<b>Clinical Assessment Protocol (CAP)</b>	<b>%</b>
cADL-Improvement	6.2
cADL – Prevent Decline	22.8
cENVIR	4.0
cFALLS – High Risk	21.0
cFALLS – Medium Risk	14.8
cIADL	48.7
cPACTIV	21.7
cPAIN – High Priority	38.4
cPAIN – Medium Priority	11.5
cRISK	35.0

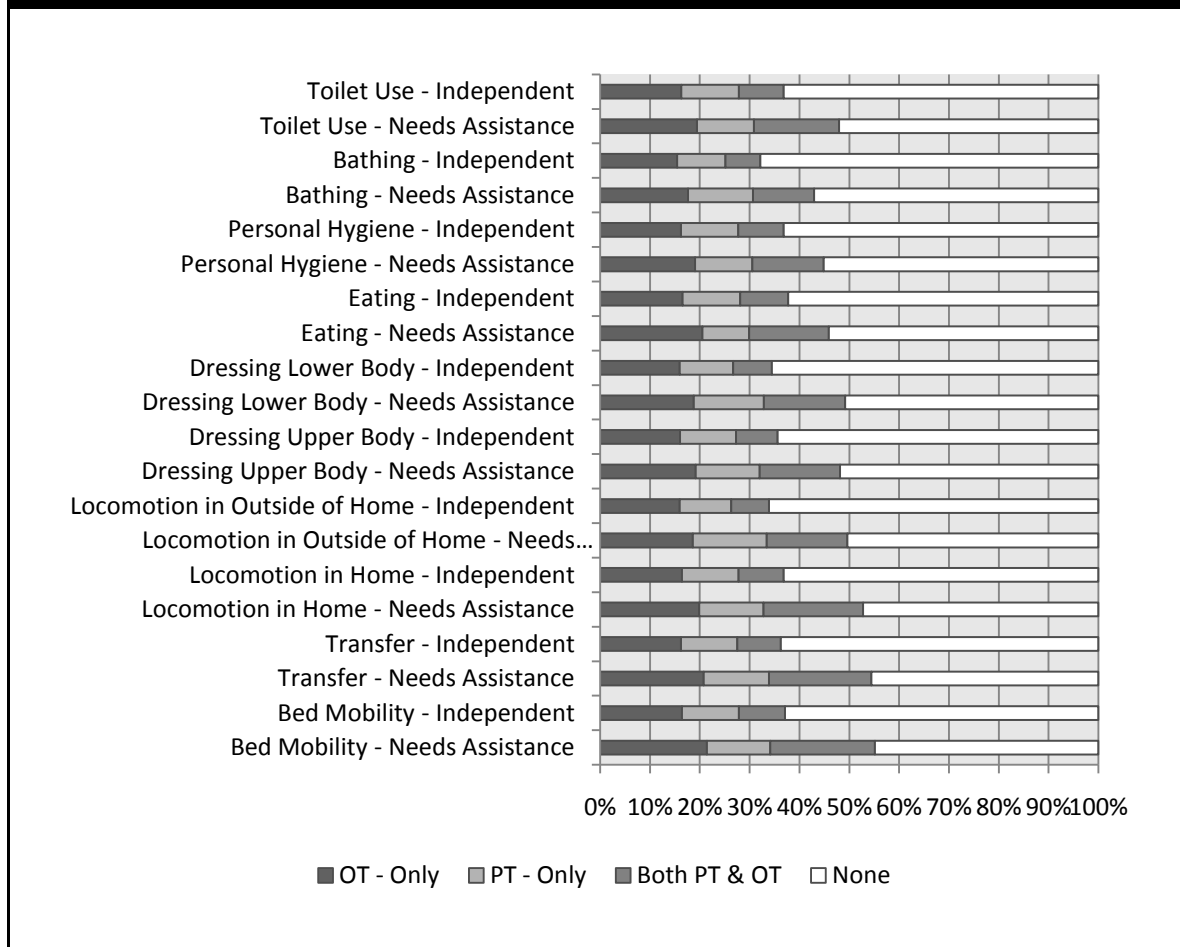
**Figure 15. Proportion Clients Receiving Rehabilitation Services by Triggered CAPs**



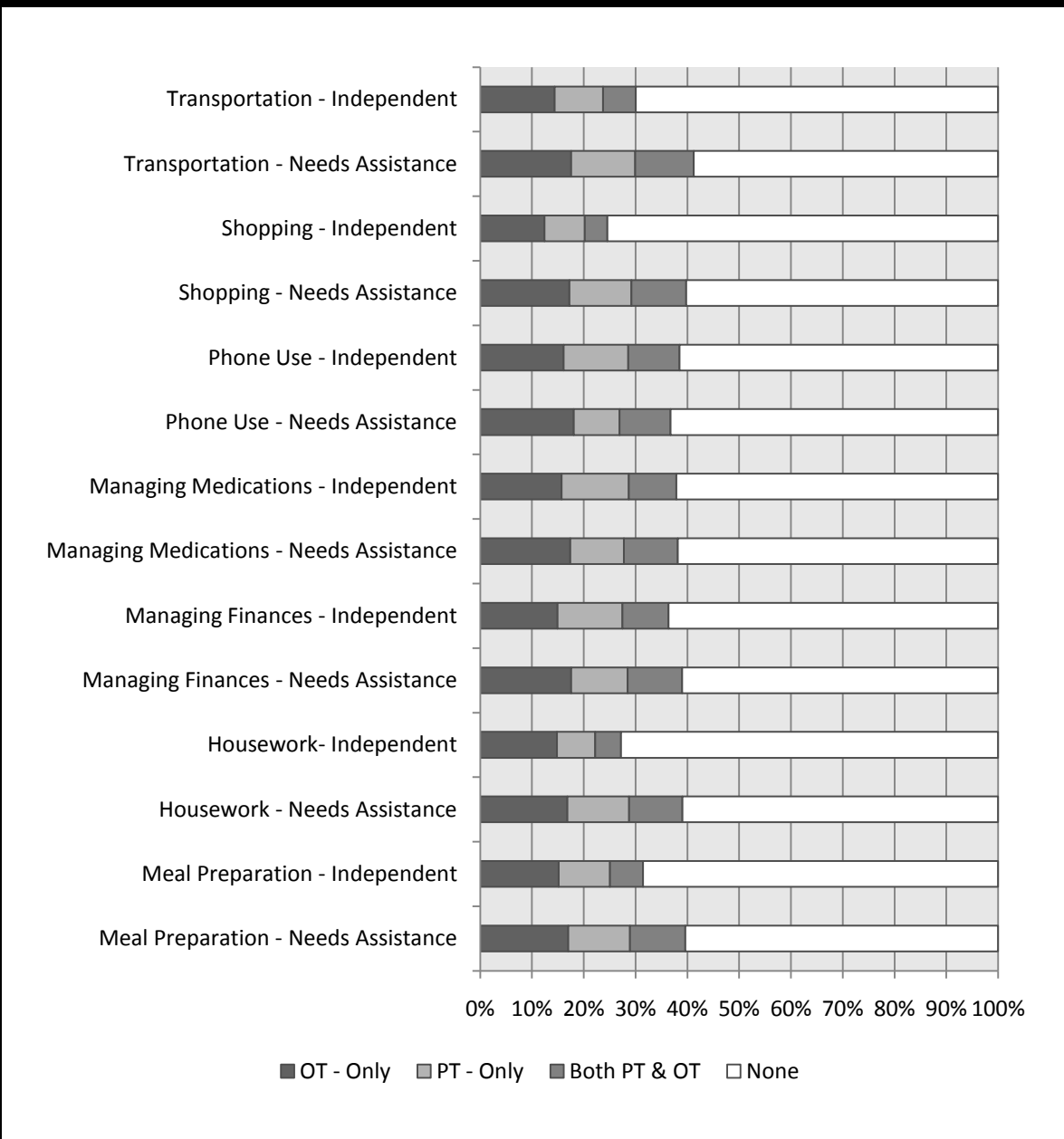
One of the most relevant need domains when examining rehabilitation therapy services is the functional impairment level of the clients. The RAI-HC contains ten specific items related directly to areas of ADL impairment and seven items for IADL impairment. Each of these items is graphed in Figures 16 and 17. Each graph indicates the proportion of clients with that impairment that receive OT-Only, PT-Only, both services and no services. Interestingly, these graphs indicate no specific trends that relate ADL and IADL

impairments to rehabilitation therapy service utilization. For each of the ADL and IADL items, a large proportion of the clients with difficulties and require some assistance in performance did not receive any rehabilitation therapy services from the Ontario Home Care System.

**Figure 16. Individual ADL Impairment Measures**



**Figure 17. Individual IADL Impairment Measures**



The home care system provides care to a client population that suffers from a wide range of disease diagnoses. The top five are: hypertension (55.1%), arthritis (45.7%), diabetes (23.3%), coronary heart disease (23.2%), and osteoporosis (19.0%). Table 8 contains the entire list of disease diagnoses and their prevalence in the overall client



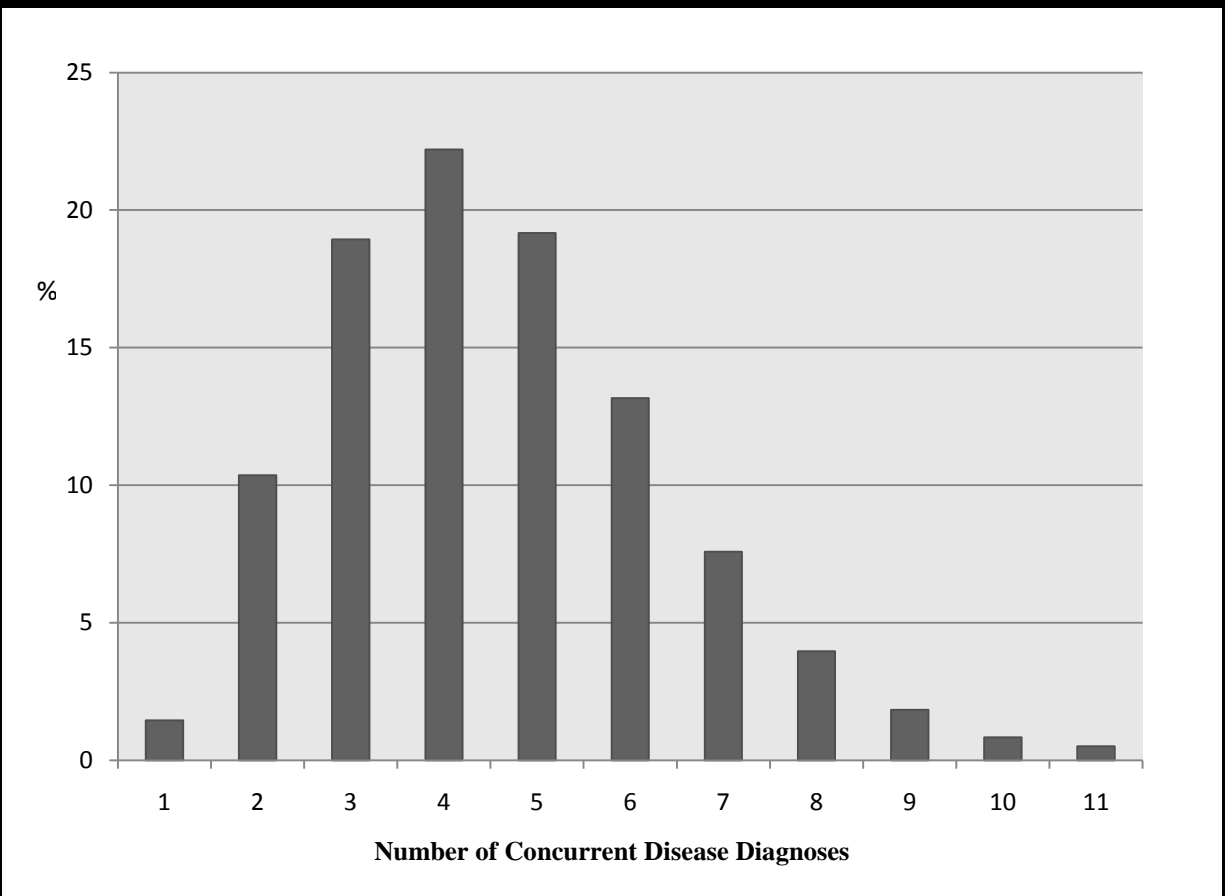
population. Also in Table 8, for each of the disease diagnoses, information is listed about the receipt of the rehabilitation therapy services for the older home care clients with that diagnosis. The clients with disease diagnoses that receive the least amount of PT are Alzheimer’s disease, Dementia not Alzheimer’s disease, and cancer. The disease diagnoses of clients that were most likely to PT services were hip fractures and other fractures.

**Table 8. Disease Diagnoses of Long-Stay Home Care Clients**

	Overall %	Receive OT-Only %	Receive PT-Only %	Receive Both %	Receive None %
Hypertension	55.1	16.8	12.0	10.5	60.3
Arthritis	45.7	16.7	13.1	10.8	59.5
Diabetes	23.3	17.4	11.7	10.6	60.2
Coronary Artery Disease	23.2	16.8	12.0	10.9	60.3
Osteoporosis	19.0	16.8	13.0	10.9	59.3
Cancer	15.9	16.2	9.9	8.3	65.6
Cerebrovascular Incident	15.2	17.9	11.8	13.4	57.0
COPD/Emphysema/Asthma	15.0	18.0	12.5	10.6	58.9
Dementia Not Alzheimer’s	13.0	17.6	6.7	6.6	69.0
Congestive Heart Failure	11.2	17.7	11.8	10.4	60.1
Irregularly irregular Pulse	10.2	16.8	12.3	11.1	59.3
Fracture	8.0	15.8	18.1	15.41	50.8
Alzheimer’s Disease	7.9	16.0	4.6	4.21	75.2
Peripheral Vascular Disease	5.9	16.3	11.4	11.3	61.0
Hip Fracture	3.9	10.9	23.2	16.2	49.7
Parkinson’s	3.5	20.3	12.9	16.0	50.8
Multiple Sclerosis	0.3	24.3	8.17	16.1	51.5

The findings above related to disease diagnoses may be considered somewhat misleading because for older home care clients, it is far more common to have multiple concurrent disease diagnoses than having one single diagnosis. For this population of older long-stay home care clients, only a small fraction has only a single disease diagnosis. The average number of diseases in the overall population was 3.58 (SD = 1.9) with a range of 0-11. The distribution of the multimorbidity count can be found in Figure 18.

**Figure 18. Multimorbidity in Long-Stay Home Care Clients**



## 4.4 Discussion

The objective of this chapter was to provide an overview of the home care client population and to examine the major characteristics of the population across rehabilitation therapy service user groups. This step is crucial in developing an understanding of a large database and it is an important component of the Knowledge Discovery in Databases process. This study fits into Phase 2 of the CRISP-DM framework being used in the overall dissertation to investigate rehabilitation services for older long-stay home care clients. The census level data collected from older long-stay home care clients across Ontario clearly indicate that only a minority (38.0%) of older long-stay clients receive OT or PT within 3 months after entering the home care system and having their initial RAI-HC assessment. (11.5% received PT only, 16.7% received OT only, and 9.9% received both). When examining over the five year period, the proportion of client receiving PT decreased after 2008 after reaching a peak (17.4% of client in 2008 to 14.1% of clients in 2010). The main reason that a relatively small proportion of the home care client long-stay client population receive rehabilitation service is due not to a lack of need or the health characteristics of Ontario's home care client population, but it is most likely due to a home care system where resources are scarce and the availability of services is tightly managed by health regions (Armstrong, Thesis Section 3.0). The decrease in PT after 2008 is interesting when considering that research studies had expected the demand for these services to increase within the province (Landry, Jaglal, Wodchis, Raman & Cott, 2008). However, more recently than these data can show, trends in rehabilitation service provision may be changing due to an increased interest in rehabilitation services for older adults and more emphasis on primary health care for Ontario's aging population (Drummond, 2012).

In terms of predisposing factors, no notable trends were found in sex, language, and marital status as these factors did not have any clear impact on the provision of either OT or PT to older long-stay home care clients. It should be noted that potential explanatory variables from the Andersen and Newman framework are not measured by the RAI-HC assessment. This information system does not incorporate information on health attitudes, values, and knowledge of the health care system, which can play a significant role in individuals accessing care and navigating through potential care options for older adults. The one predisposing factor that did have a major impact on service provision was age. Proportionately, clients over the age of 90 received less PT than all younger age categories. Further investigation into this finding is warranted as this finding may also be a function of other factors including clients receiving PT from outside the home care system, client unwillingness to receive PT, and higher levels of cognitive impairment (also associated with decreased PT) rather than simply due to advanced chronological age.

For enabling factors, the most notable finding was the large amount of variation in the provision of both OT and PT across the 14 health regions of Ontario (approximately 40% difference in the CCAC with the lowest rate of provision to the CCAC with the highest rate). These findings are not entirely surprising, as previous research studies have indicated that rehabilitation service provision may depend more on where the client lives than on a client's health care and functional needs (Mahomed et al. 2004, Poss, 2010). These findings will directly impact predictive modeling procedures in Phase 4 of the CRISP-DM. Due to this variation of service provision across regions, it will be important to incorporate the impact of regional clustering into any analyses that examine service provision through the use of hierarchical or multilevel modeling approaches. Currently, provincial government policies

state that there should be equal access to care for all Ontarians across the entire province.

These descriptive findings indicate that for older clients in the home care system, access may differ depending on a client's home region.

Similarly to the predisposing factors, there were no well-defined univariate trends in education levels of the clients. However, it can be noted that there was a slight increase in PT service provision for clients who had a higher level of education. When examining characteristics of the long-stay clients' caregivers, the clients whose caregivers had indicated that they (a) were not satisfied with their supports, or (b) were experiencing distress, were provided with higher rates of OT compared to the clients whose caregivers did not report (a) or (b). It is currently unclear why these clients would receive higher rates of OT and further exploration of this phenomenon is warranted.

Examining the client population's need factors led to a number of interesting findings. Firstly, after examining five of the outcome scales that are embedded within the RAI-HC, it was clear that a client's level of cognitive impairment has an impact on the provision of rehabilitation therapy services. This finding coincides with the results of the Phase 1 qualitative study. In a series of semi-structured interviews, key stakeholders from the Ontario Home Care System indicated that cognitive impairment can have an influence on a case manager's decision to provide PT. PT relies on the client performing and practicing exercises and cognitive impairment can make this difficult. On the other hand, research has indicated positive benefits of PT in cognitively impaired elderly patients (Heyn, Abreu & Ottenbacher, 2004; Columbo et al., 2004; Diamond et al., 1996). It is likely that many clients with cognitive impairments could benefit from these services but do not receive any.

The interRAI CAPs were also used to identify potential need factor correlates of rehabilitation service provision. It is clear that not every home care client who could benefit from receiving OT and PT is provided with this type of care. This is most likely due to the current environment in home care where resources are scarce and services must be targeted to a select few. Therefore, there is a current need for research to explore ways to improve the targeting of resources in order to make the home care system more efficient, effective, and safe. The results also clearly indicated that those clients who have been identified as having an issue with their home environment are more likely to receive OT service provision. Again these results verify the findings of the Phase 1 qualitative study where it was clearly indicated that OT is most frequently used in the Ontario Home Care System for environmental assessments. The data also illustrated that for those clients who trigger the ADL CAP for improvement, only a very small proportion receive any PT (6% receive only PT, 6% receive PT and OT). This finding confirms the findings from Phase 1 that PT is not currently being used to address recent functional decline or below capacity performance of older long-stay clients. Those results from the qualitative research indicated that PT was mostly provided to short-stay individuals leaving the hospital post-surgery (e.g., total hip replacement, total knee replacement, hip fracture).

When examining the specific ADL and IADL impairments, again no clear trends were apparent when looking at each of the functional impairment items independently. This lack of clear trends was somewhat surprising, as it is believed that functional impairments are what typically drive the provision of rehabilitation therapy services in the Ontario Home Care System. The lack of obvious trends between rehabilitation therapy service provision and ADL/IADL impairments contradicts the findings from the interviews from Phase 1.

Findings from that study indicated that decisions to provide rehabilitation services were based mostly on functional impairments. The lack of any obvious trends could be the result of looking at the individual items independently, where combinations of impairments may be more telling. The ADL Hierarchy Scale and the IADL Capacity scale use these individual items to create a scale score. These scale scores indicated a slight trend towards more OT and PT services for those with higher levels of impairment. However, many of the clients at the high end of those two scales did not receive any rehabilitation therapy services.

When examining rehabilitation therapy service user groups across the list of diseases, a few clear patterns of service provision were found. Clients with a diagnosis of dementia (Alzheimer's disease, and dementia not Alzheimer's disease) receive the lowest rates of PT relative to all other disease diagnoses. This coincides with the findings related to the CPS, where increased levels of cognitive impairment were associated with lower rates of PT provision. Despite the difficulties involved with conducting PT with clients with dementia, some studies have indicated potential benefits of PT for older adults with dementia (Teri et al., 2003; Rolland et al., 2007; Toulotte et al., 2003).

The descriptive analyses also briefly examined multimorbidity in the home care client population. The findings indicate that multimorbidity is very common in home care clients. Future research should investigate this further by looking at common patterns of multimorbidity. These findings add to the growing knowledge that home care clients are an increasingly complex and heterogeneous population (Murtaugh et al., 2009). Care plans, treatments, preventive approaches for these older adults should not be designed to focus on single diseases; home care services need to incorporate strategies to deal with patterns of multimorbidity. For instance, future research may be able to indicate if there are

combinations of disease diagnoses that are best addressed using rehabilitation therapy services. Conversely, there may be combinations where these rehabilitation services should not be considered due to a lack of effectiveness.

After reviewing the characteristics of the home care population and their use of rehabilitation services, it is clear that home care clients are a large complex and heterogeneous population with a wide range of disease diagnoses, physical impairments and health care needs. Although these clients form a heterogeneous population, common patterns and trends may be discovered using modern analytical techniques from the fields of data mining and machine learning. Due to the increasing size of the Ontario over-65 population, improved effectiveness and efficiency of rehabilitation services in home care is paramount. There is currently much room for improvement of the rehabilitation therapy services for older home care clients in Ontario. This current study was used to gain a better understanding of the RAI-HC data and OT/PT service use patterns in the older long-stay client population of the Ontario Home Care System. These results, in conjunction with the results of the qualitative research, will be used to inform and guide the quantitative analyses in the following two chapters. The first of these will utilize the K-means clustering algorithm to explore patterns of health characteristics in the population of rehabilitation therapy service users. The second study will utilize various predictive modeling techniques to develop an understanding of what client factors drive the provision of OT and PT to older adults in the Ontario Home Care System Phase 1 (qualitative study) and Phase 2 (data understanding) activities will be used to inform the development of these models through allowing the analyst to first build an understanding of the therapy services (Phase 1), followed by the familiarization with the data (Phase 2). Phase 2 also allows for the



identification of data quality problems and the discovery of first insights into the data prior to any modeling procedures.

The entire research project, as guided by the CRISP-DM framework aims to inform provincial and regional policies while also improving the ability for decision making at the client level. The findings of this chapter, while solely descriptive, are useful in expanding the understanding of therapy services for older adults in a provincial home care system.

## **5.0 EXAMINING THE HETEROGENEITY OF A COMPLEX GERIATRIC POPULATION: K-MEANS CLUSTER ANALYSIS OF REHABILITATION SERVICE USERS IN THE HOME HEALTH CARE SYSTEM OF ONTARIO**

**This chapter is based on a study first reported in the Archives of Physical Medicine and Rehabilitation. The primary publication can be found at:** Armstrong JJ, Zhu M, Hirdes J, Stolee P. K-Means Cluster Analysis of Rehabilitation Service Users in the Home Health Care System of Ontario: Examining the Heterogeneity of a Complex Geriatric Population. Arch Phys Med Rehab. 93(12): 2198-2205.

## Overview

### **OBJECTIVE**

To examine the heterogeneity of clinical characteristics of home care clients who utilize rehabilitation services by using the K-means algorithm to identify previously unknown patterns of clinical characteristics.

### **DESIGN**

Observational study of secondary data collected using the provincially mandated RAI-HC information system.

### **SETTING**

Ontario Home Care System.

### **PARTICIPANTS**

This study focused on assessment information collected on 150,253 older (>65) home care clients using the provincially mandated RAI-HC data system.

### **MAIN OUTCOME MEASURES**

This study analyzed assessment information from every long-stay (>60 days) home care client who entered the home care system between 2005 and 2008 and who utilized rehabilitation services within three months of their initial assessment. The K-means clustering algorithm was applied using 37 variables from the RAI-HC assessment.

### **RESULTS**

The K-means cluster analysis identified seven relatively homogeneous subgroups that differed on characteristics such as age, sex, cognition, and functional impairment. Client profiles were created to illustrate the diversity of this geriatric population.

### **CONCLUSION**

The K-means algorithm provided a useful way to segment a heterogeneous rehabilitation client population into more homogeneous subgroups. This analysis provides an enhanced understanding of client characteristics and needs, and could enable more appropriate targeting of rehabilitation services for home care clients.

## 5.1 Introduction

With the aging of the population and pressures to limit the use of inpatient/hospital services, home-based services are an increasingly important component of the health care system. In the Canadian province of Ontario as well as many other jurisdictions, many older adults rely on services from the home care sector to continue living in their own homes. Included in the array of services offered by home care in Ontario are rehabilitation therapies [physiotherapy therapy (PT) and occupational therapy (OT)], which have been demonstrated to be effective for supporting the independence of older persons in home-based settings (Gill et al, 2002; Gitlin, Hauck, Winter, Dennis, & Schulz, 2006; Gitlin et al., 2006; Giusti, Barone, & Oliveri, 2006; Crotty, Whitehead, Miller, & Gray, 2003; Kuisma, 2002; Landry, Jaglal, Woodchis, Raman, & Cott, 2008).

As the number of older home care clients needing PT and OT services is expected to increase in the years to come (Landry et al., 2008) a better understanding of the population characteristics and the differing needs of these clients is needed if we want to effectively plan and efficiently deliver rehabilitation services. Currently in Ontario, over one million OT and PT visits to home care clients are provided per year through Community Care Access Centres (CCACs), the organizations that coordinate home care services and long-term care placement in Ontario (Ontario Home Care Association, 2011). Despite the importance of these therapeutic services and the large volume of service provision, little is currently known about home care rehabilitation clients and whether there are distinct subgroups that exist within this population that could benefit from specialized services.

Efforts to understand the health and service needs of an aging population have commonly focused on identifying predictors and risk factors related to outcomes such as

service utilization (Hastings, Purser, Johnson, Sloane, & Whitson, 2008; Alkema, Reyes, & Wilber, 2006), institutionalization (Bellelli, Magnifico, & Trabucchi, 2008; Luppá et al., 2009), functional improvement/decline (Hébert, Brayne, & Spiegelhalter, 1999; Formiga, Ferrer, Pérez-Castejon, Olmedo, & Pujol, 2007) and mortality (Ensrud et al., 2007; Kulminski et al., 2008). Less emphasis has been placed on understanding the individual differences and naturally occurring groupings within study populations (Lafortune, Béland, Bergman, & Ankri, 2009). Medical research studies tend to treat all patients as the same, controlling for individual patient differences as covariates in statistical models (Luke, 2005). Although important findings can arise from using a traditional approach that statistically controls for individual differences, disregarding the heterogeneity found in patient populations can conceal meaningful patterns in patient characteristics.

Typically in medical and epidemiological research, the focus is on population averages and heterogeneity is actively suppressed and treated as noise (Kravitz, Duan, & Braslow, 2004; Davidoff, 2009); however, ignoring individual differences by focusing on averages can lead to misleading research results and can potentially harm patients. For example, population heterogeneity has been shown to cause errors in calculating the cost-effectiveness of interventions as well as in the results of regression models and decision analytic models (Henderson & Oman, 1999; Kuntz & Goldie, 2002; Zaric, 2003; Koffijberg, Rinkel, & Buskens, 2009). Carefully considering patient heterogeneity may be necessary to obtain unbiased model outcomes when making uniform recommendations for a heterogeneous population (Koerkamp, Stijnen, Weinstein, & Hunink, 2009), such as policy changes within health services. The impact of heterogeneity is potentially even stronger in geriatric populations due to the complexities in clinical status that are associated with aging

(Callahan, Thomas, Goldhirsch, & Leipzig, 2002; Grimley, 2000). Older patients are much more likely to have differing patterns of numerous medical problems, multiple chronic diseases, atypical presentations of medical conditions, multiple prescription medications (polypharmacy), cognitive impairments, and sensory impairments (Canadian Institute for Health Information, 2012; Corretge, Doubal, & Mead, 2010; Rajska-Neumann & Wieczorowska-Tobis, 2007; Cresswell, Fernando, McKinstry, & Sheikh, 2007; Peron, Marcum, Boyce, Hanlon, & Handler, 2011; Lindsay et al., 2002; Miller, Zylstra, & Standridge, 2000; Van Den Bussche et al., 2011; Britt, Harrison, Miller, & Knox, 2008). This increased complexity in geriatric patient populations leads to care populations that are challenging to manage (Murtaugh et al., 2007). Only a handful of more recent studies have directly focused on uncovering the heterogeneity found among older patients including patients with hip fracture (Penrod et al., 2007; Young, Xiong, Pruzek, & Brant, 2010), cardiac problems (Lindgren et al., 2008; Fukuoka, Lindgren, Rankin, Cooper, & Carroll, 2007), and frailty (Lafortune, Béland, Bergman, & Ankri, 2009; Montero-Odasso et al., 2009).

The qualitative research in Phase 1 of the dissertation project found that the population of older home care clients that utilize rehabilitation services are complex, consisting of home care clients with a wide variety of health issues. Phase 2 of the project examined many variables of rehabilitation users independently, one variable at a time. The aim of this chapter is to explore the heterogeneity of home care clients who utilize rehabilitation services by discovering previously unidentified patterns of clinical characteristics, and create client profiles to illustrate the different subgroups found within this client population

## 5.2 Methods

This study used data collected based on the Resident Assessment Instrument – Home Care (Morris et al., 1997; Landi et al., 2000). The RAI-HC assessment system has been mandated for use for all clients expected to use home care services for more than 60 days, which provides Ontario census-level data on long-stay home care clients. For this exploratory cluster analysis, we utilized the RAI-HC data of 150,253 clients who received rehabilitation services (OT or PT) within the first 3 months of their initial home care assessment. Data were collected between April 2005 and August 2008. Ethics clearance was received from the University of Waterloo’s Office of Research Ethics.

The RAI-HC is one of a suite of standardized assessment tools developed by the international interRAI consortium (Hirdes et al., 1999). The instrument contains a wide variety of assessment items including demographic information, cognition, physical functioning, disease diagnoses, nutrition/hydration status, environmental assessment, and service utilization. Collected by frontline workers using data entry software, RAI-HC assessments have checks during data input that constrain item entries as non-missing, within correct ranges, and with logical checks.

Due to the large number of variables available within these assessment data (300+), variables to be used in the analysis were selected through quantitative variable selection techniques (Proc Varclus in SAS 9.1) and consultation with fellow researchers from the infoRehab team (<http://www.inforehab.uwaterloo.ca>) who have knowledge of rehabilitation services for home care clients. In total, 37 variables were used for the K-means cluster analysis; these included activities of daily living (ADL), instrumental activities of daily living (IADL), disease diagnoses, sex, Changes in Health, End-Stage Disease, Symptoms

and Signs, a health instability outcome measure (CHESS; Hirdes, Frijters, & Teare, 2003), and age. A complete list of all the measures used and their brief descriptions can be found in table 9. This table also includes the proportion of the entire rehabilitation service user population.

**Table 9. Variables used in K-Means cluster analysis.**

Measure	% of Overall Client Population	Measure	% of Overall Client Population
IADL: Ordinary Housework	94.8	Heart disease	26.3
IADL: Shopping	91.7	ADL: Transfer	23.7
IADL: Meal Preparation	82.4	Osteoporosis	23.6
ADL: Bathing	81.2	ADL: Eating	23.2
IADL: Transportation	75.3	ADL: Locomotion in Home	22.7
Unsteady Gait	67.6	History of stroke	19.1
Sex (Female)	66.7	COPD/Emphysema/Asthma	18.3
IADL: Managing Medications	65.0	Frequent Falling	17.0
Daily Pain	60.8	Cancer	13.7
Arthritis	55.4	Psychiatric Diagnosis	13.3
ADL: Dressing Lower Body	45.4	Congestive Heart Failure	12.9
ADL: Dressing Upper Body	38.5	Dementia	12.6
Living Alone	35.1	CHESS 2+	12.2
Trouble with Decisions Making	32.5	History of Fracture	11.5

\*Margin of error for these percentages is  $\leq 1\%$

Age was included in the K-Means cluster analysis (Standardized using Euclidean Distance)

Average Age = 76.8 years; Sample Size (n) = 150,253

COPD = Chronic obstructive pulmonary disease

ADL=Activities of Daily Living

IADL=Instrumental Activities of Daily Living

Thirteen ADL and IADL items were included that covered a variety of physical functioning domains. These items were reduced to a dichotomous form (independent vs. dependent). Fourteen disease diagnosis categories were also included and these were also coded dichotomously as present/not present. Additional variables included in the cluster analysis were sex, age (standardized using Euclidean distance to reduce the influence of age's wide range of values), presence of daily pain, multiple recent falls (>2 vs. <2),



unsteady gait, problems with decision making, presence of pressure ulcers, the CHES score (2+ vs. <2;), and home living status (alone vs. living with caretakers).

### **K-Means Cluster Analysis**

In this study, we sought to discover patterns of clinical features among home care clients by using the K-means algorithm (MacQueen, 1966), a popular data partition method widely-used in many fields including data mining, pattern recognition, decision support, machine learning, and image segmentation. This algorithm is considered by the data mining and machine learning community to be an unsupervised learning technique as it searches for patterns amongst input variables without using an outcome variable to dictate how the pattern is formed. In other words, K-means clustering is a way to use data to uncover natural groupings within a heterogeneous population. To uncover patterns, the algorithm starts by first assigning data points into random groups. The group centers are then calculated and the group memberships are re-assigned based on the distances between each data point and the group centers. This process is repeated until there are no changes in the group memberships from the previous iteration. With the exception of age, all variables used in the k-means cluster analysis were dichotomized. This allows for easy interpretation as a mean score of a dichotomous variable directly relates to the proportion of clients with a score of 1.

To perform this analysis, we used the procedure FASTCLUS in SAS. We chose the K-means algorithm and the SAS implementation in particular because of its suitability for analyzing relatively large data sets as well as its use of a spacing heuristic for initial group assignments in order to avoid sub-optimal solutions. All analyses were performed in SAS 9.1.

Due to the fact that K (the number of clusters) needs to be specified prior to analysis, we utilized an iterative process to explore a range (2-20) of possible cluster solutions. For

each possible cluster solution, we examined three statistical criteria: (1) the cubic clustering criterion (Caliński & Harabasz, 1974), (2) the pseudo-F (Milligan & Cooper, 1985), and (3) the squared multiple correlation. To compare these three criteria over the range of solutions, each of three statistics were graphed by the number of potential clusters.

### **One-Year Service Outcomes**

In addition to the clinical variables collected with the RAI-HC, service outcome data were available for each of these clients for the time period of one year after the clients' initial home care assessment. These service outcomes indicate whether the clients left the home care system and include: successful completion of care plan (released to live at home), hospitalization, long-term-care placement, and mortality. After the cluster analyses, service outcomes were utilized to examine outcome differences between the clusters.

### **5.3 Results**

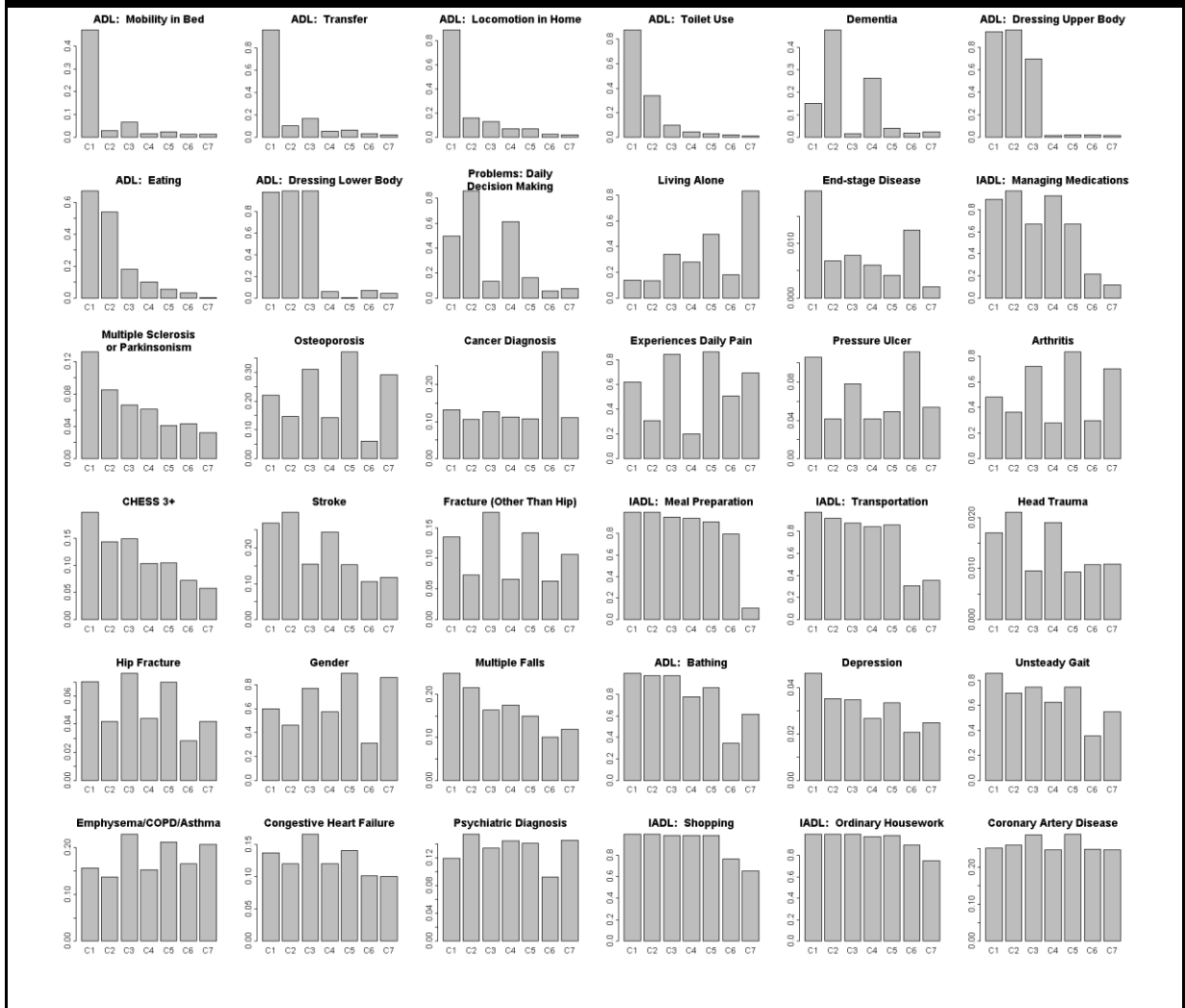
The first column in Table 1 presents the variables used in the cluster analyses as well as the full sample baseline demographic, functional, and health characteristics. For the entire sample, the average age was 76.8 (SD = 13.2) years, 12.6% were diagnosed with dementia (Alzheimer's and non-Alzheimer's dementias), 5.6% had a previous hip fracture, 19.1% had stroke, and two-thirds of these clients were female (66.7%). The majority of clients had daily pain (60.8%), arthritis (55.4%), and unsteady gait (67.6%). Due to the extremely large sample size, margin of error for these percentages is  $\leq 1\%$ . From this process outlined in the methods section, we determined that a 7 cluster solution was most appropriate for this data.

The approximate overall R-squared of the K-means (K=7) cluster analysis was 0.1305 which represents the estimated overall variance accounted for by the clusters.

### **Client Clusters**

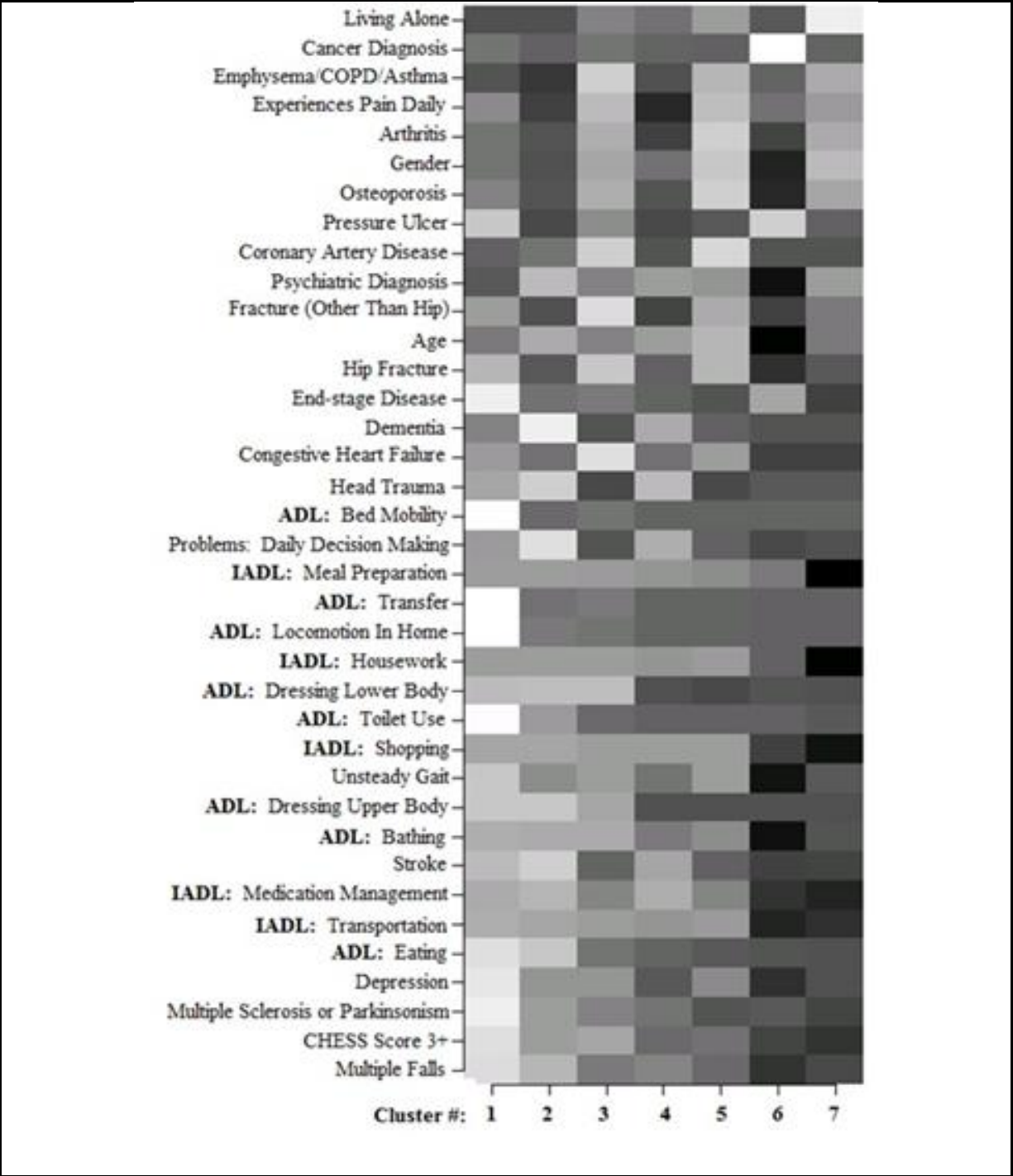
Figure 19 contains 36 bar graphs showing the proportions in each of the seven clusters for the dichotomous measures used in the cluster analysis. This series of graphs illustrates the variability and heterogeneity between the subgroups on a measure by measure basis. To further explicate the heterogeneity found within this population, a heat map technique was utilized to create Figure 20. This heat map is a graphical illustration of the relationship between the seven clusters and the distributions of each of the 37 variables used in the cluster-means cluster analysis.

**Figure 19.** Cluster proportions for dichotomous variables used in K-means cluster analysis.



**Note:** The variables are ordered by between-cluster variations (from high to low variation).

**Figure 20.** Heat map of K-Means Cluster Analysis Results – 7 Clusters by Variables Included in the Analyses



**Note:** The colours in this heat map represent quantiles. Black boxes indicate the cluster is on the low end of the distribution for the particular variable. White boxes indicate that the cluster is on the high end of the distribution for the particular variable. Clusters are ordered in similarity to each other. Variables are ordered in similarity to each other, in terms of their distribution over the seven clusters.

## **Cluster Profiles**

In order to describe the patterns found within this client population, cluster averages were used to create profiles for each cluster, highlighting the major and differential characteristics of the seven subgroups. Clusters were ordered from most dependent to the least dependent, based upon the measures used in the analysis.

### **Cluster 1 (9% of population)**

This cluster can be described as dependent and immobile clients with cognitive problems. This cluster had an average age of 76.3 years and was 60% female. High rates of dementia (15%), stroke (27%), neurological disorders (Multiple sclerosis and Parkinson's disease; 13%), heart disease (25%), and incontinence (58%) are found in this cluster with 20% of this cluster having a high score on the CHESS scale (health instability). This cluster was highly dependent across all ADL and IADL domains, including a relatively high rate of dependency on bed mobility (47%), transferring between surfaces (96%), and locomotion in home (89%).

### **Cluster 2 (23% of population)**

The largest of the seven subgroups, these clients were in general dependent but mobile clients with cognitive problems. Cluster 2 had an average age of 78.9 years and was 46% female. Similar to Cluster 1, Cluster 2 was characterized by clients having a high rate of dementia (48%) and problems with daily decision making (86%). However, this cluster differs from Cluster 1 in that these clients were relatively mobile (bed mobility: 3% required

assistance; transferring between surfaces: 10%; locomotion in home: 7%) yet they were still highly dependent in performing all other ADL and IADL.

**Cluster 3 (14% of population)**

This client cluster had an average age of 76.5 years and was primarily female (77%). The majority of this cluster reported daily pain (84%). Out of all 7 clusters, this cluster is most likely to self-report poor health (28%) and 75% of these clients are in danger of falling due to unsteady gait. On average, they required assistance with ADL and IADL domains including meal preparation (95%), housework (100%), managing their medications (67%), shopping (99%), transportation (87%), dressing their upper body (70%), dressing their lower body (99%), and bathing (97%).

**Cluster 4 (15% of population)**

Primarily female (89%) with an average age of 79.3 years, this cluster is characterized by their need for help with IADLs: housework (99%), medication management (67%), shopping (98%). Of the 7 subgroups, this group of clients had one of the highest proportions of clients with arthritis (84%) and reporting daily pain (90%). Approximately half of all cluster 4 members lived alone (49%). Thirty-seven percent had a recorded diagnosis of osteoporosis. Compared to clusters 1-3, this cluster of clients was relatively independent; they did not require assistance with dressing their upper body (2%) or dressing their lower body (0.1%).

**Cluster 5 (19% of population)**

Cluster 5 had an average age of 78.2 years and was 58% female. This group has the smallest proportion of clients reporting daily pain (20%) yet they had a high prevalence of

dementia (26%) and problems with daily decision-making (61%). Clients within cluster 5 were much more independent in ADLs compared to clusters 1-4, with the exception of bathing (78% required assistance). What makes this cluster distinct is that a large majority of these home care clients required assistance in all four IADL domains (managing medications 93%; housework 98%; shopping 98%; transportation 84%), most likely due to their impaired cognition.

**Cluster 6 (10% of population)**

The youngest of all of the clusters with an average age of 70.6 years of age, this subgroup is characterized by being primarily male (69%). These clients had low rates of stroke (11%), osteoporosis (6%), multiple falls (10%), and cognitive impairment (5.8% had troubles with daily decision making, 1.8% with a dementia diagnosis). These home care clients mainly required assistance with housework (90%) and shopping (76%) and were relatively independent in bathing (35%), transportation (30%), and medication management (22%). Surprisingly, this cluster had a rate of cancer (29%) that was approximately 3 times the rate of the other clusters.

**Cluster 7 (10% of population)**

Clients in this subgroup were primarily female (86%) with an average age of 76.4 years. A large proportion of these clients reported having arthritis (70%) and osteoporosis (29%) and the majority lived alone (83%). Cluster 7 had low rates of both dementia and problems with daily decision making - 2% and 8% respectively. The majority of this cluster also reported daily pain (69%) and arthritis (70%). In terms of ADL and IADL impairments, this cluster needed assistance mainly with housework (75% required assistance) and bathing (61%). This cluster can be considered the most independent of the 7 subgroups.



## One-Year Service Outcomes

For the outcome of successfully completing their care plan, the percentage of clients with this outcome ranged widely across the clusters. The most successful clusters were clusters 6 (36%) and 7 (29%), while the least successful clusters were 2 (13%) and 1 (14%). Clusters 1 and 2 also had the highest proportion clients who suffered mortality within one year of assessment (11% and 8% respectively). Additionally, clusters 1 and 2 also had the highest proportion of clients placed into long-term-care (8% and 11% respectively). The hospitalization rates ranged between 11% and 17% with the highest rates falling within clusters 1, 2, 3, and 4. See table 10 for details.

**Table 10. One-Year Outcome (% of clients in each cluster)**

Cluster	Successfully Complete Care Plan	Hospitalized	Long-term-care Placement	Mortality
1	14.4	16.9	7.9	11.2
2	20.4	16.5	4.3	6.7
3	22.2	15.1	4.5	4.8
4	13.2	14.4	11.0	7.9
5	22.0	13.3	6.4	6.1
6	36.8	11.2	2.0	7.0
7	28.5	10.9	2.2	3.3

\*Margin of error for these percentages is  $\leq 1\%$

## 5.4 Discussion

The findings of this cluster analysis demonstrate that rehabilitation service users in the home care system are a heterogeneous group that can be grouped into smaller, more homogeneous clusters based upon available health information. By applying the K-means clustering algorithm, we were able to identify seven relatively homogeneous subgroups from within the entire population of rehabilitation service users in the Ontario home care system.

This paper illustrates the use of an alternative approach to dealing with individual differences in complex health service data. The need to better understand naturally occurring groupings within client populations in home health care systems will grow in the upcoming years as the aging population and the multiplicity of health care needs will lead to home health care populations that are increasingly complex and challenging to manage (Murtaugh et al., 2009). Despite the fact that caring for elderly individuals has long been recognized as complex, medical science has resisted shifting away from traditional linear conceptual models (Mitnitski, Mogilner, Graham, & Rockwood, 2003). Developing more robust models that permit the incorporation of the multifactorial complexity that is inherent in geriatric care is necessary for progress in this field (Marsland & Buchan, 2004). Strategies based on combining available clinical data with machine learning techniques, which have the ability to handle complexity (Marsland & Buchan, 2004), can enhance our ability to understand geriatric patient populations and to target our limited health care resources, which would benefit both patients and the health system.

The resulting seven clusters clearly illustrate that functional abilities, as measured by the ADL and IADL measures, can cluster together to form patterns across the population of home care clients that are provided with rehabilitation services. Clusters one and two were

very dependent for many tasks of daily living including bathing, dressing lower body, and transportation. In contrast, clusters six and seven were relatively independent yet were still provided with some rehabilitation services. These differences demonstrate that there are subgroups within the overall rehabilitation client population. Home health care is currently restrained by having limited resources; the development of this type of information can be used to better target individuals who are at greatest need and/or to those who would benefit most. Because of the heterogeneity found within this client population, we can assume that services required, the impact of services, and the predictors for various outcomes vary significantly across the entire population of rehabilitation service users. More research is needed to determine what types of clients benefit most from rehabilitation services and what types of clients require more/less services. The consideration of heterogeneity in care populations is also important for future work on how electronic health information can be used to better target services, and how data can be used to inform service planning including prioritizing clients for rehabilitation services.

In this study we were able to look at the one-year outcomes of the home care clients and significant variation was found across the identified clusters. These differences provide some validation of the results of the cluster analyses, however, this study should be considered exploratory and further analyses will be needed to further validate the results and assess their implications. Although there is never one perfect solution when it comes to population segmentation in complex care populations, further use of cluster analyses will assist in discovering the common clinical patterns that can be used to enhance our understanding of the rehabilitation service users. Future research will need to further examine the impact of client clusters in rehabilitation services in the Ontario home care

system and explore how this information can be used in health care decision making processes and in the creation of decision support systems.

### **Study Limitations**

This study has a number of limitations. The cluster analysis focused on long-stay rehabilitation clients who received rehabilitation services and did not include individuals who could benefit from rehabilitation therapy but did not receive it. Furthermore, the RAI-HC data system only captures long-stay clients and therefore these findings cannot be generalized to all home care clients. The K-means algorithm also has limitations. As pointed out earlier, the number of clusters has to be specified prior to running analyses. This is the major disadvantage of this algorithm as the ideal number of clusters is most often unknown in exploratory analyses.

### **Conclusions**

This investigation identified seven subgroups of rehabilitation service users within the long-stay home care client population in Ontario. This work supports the idea that older home care clients form a diverse, heterogeneous population and clustering methodologies can be used to further our understanding of the patterns or groups that naturally form within the rehabilitation client population. Researchers can use cluster analyses within large administrative databases to focus on pattern discovery in both a general fashion (as done in this study) or in a more targeted fashion focusing on specific domains of interest (i.e., physical functioning, cognition, chronic disease diagnoses, etc.).

## **6.0 PREDICTORS OF REHABILITATION SERVICE PROVISION FOR OLDER LONG-STAY CLIENTS IN THE ONTARIO HOME CARE SYSTEM**

### **Overview**

#### **BACKGROUND**

Despite the home care sector's increasing importance within Canadian health care systems and the growing need for rehabilitation services for older adults within these systems, we have a limited understanding of the drivers of rehabilitation service provision within the home care sector. Many older individuals who have suffered strokes, musculo-skeletal disorders, functional decline, and other age-related health deficits receive rehabilitation services provided by the homecare system. Although there is evidence that home-based rehabilitation can improve functional outcomes in older adults, many clients do not receive the rehabilitation services they need due to limited resources.

#### **OBJECTIVE**

The objective of this study is to identify client characteristics that are most associated with the provision of occupational therapy services and physiotherapy services in the Ontario Home Care System. Due to previous research findings and the hierarchical nature of the data, regional variation will be a sub-focus of the analyses.

#### **DESIGN**

Observational study of secondary data.

#### **SETTING**

Home Health Care System in Ontario, Canada

#### **PARTICIPANTS**

This study focused on all long-stay clients (> 60 days) in the Ontario Home Care System (2005-2010). Each client's initial RAI-HC assessment (n = 299 262) was linked to service use data from the Ontario Association of Community Care Access Centres.

#### **ANALYTIC APPROACH**

Three types of modeling techniques were utilized: Logistic regression, multilevel logistic regression, and the Random forests algorithm. The dependent variables in these analyses were occupational therapy provision and physiotherapy provision within 3 months of the assessment.

#### **RESULTS**

There was a large regional variation in service provision for both OT and PT. After accounting for this regional variation, needing a home environment assessment was the most powerful client-level predictor of receiving OT. The most predictive factors from the multilevel logistic regression for receiving PT were having hip fracture and having impairment in instrumental activities of daily living. Furthermore, cognitive impairment and dementias were highly predictive of not receiving PT. Random forest models indicated that

age, IADL impairment, health instability, and the client's education level were the most influential variables for predicting both OT and PT service provision.

## **CONCLUSION**

The finding of large regional differences across Ontario suggests that access to rehabilitation services in home care is not equal for all older adults in the province. This study was also able to identify client characteristics that are most highly associated with OT and PT service in the Ontario Home Care System. These findings inform policy makers of the characteristics of older adults that have been associated with rehabilitation therapy service provision in past practices. These findings should be considered in the development of initiatives designed to adapt the home care system to meet the changing needs of our aging population.

## 6.1 Introduction

Rehabilitation therapies in home-based settings for older adults have been shown to result in similar or superior outcomes than inpatient rehabilitation services (Gill et al., 2002; Kuisma et al., 2002; Crotty et al., 2003; Gitlin et al., 2006a; Gitlin et al., 2006b; Giusti et al., 2006). Stolee and colleagues (2012) recently conducted a systematic literature review that found home-based rehabilitation produced outcomes either equal or better than rehabilitation based within hospitals. For older adults in home care, the goal of rehabilitation therapy services is to allow individuals to maintain or improve physical functioning, quality of life and their overall independence while living within their community (Côté & Fox, 2007). Home care services such as occupational therapy (OT) and physiotherapy (PT) have the potential to save money for the health system downstream (by reducing falls, emergency room use, dependencies), while also effectively improving the quality of life for people who may otherwise be hospitalized or institutionalized (Anderson, 2002).

Despite the evidence has supported the effectiveness of rehabilitation in the home, many older home care clients are not provided with the rehabilitation services they need (Borrie et al., 2001; Jaglal, 2003). More specifically, past research has demonstrated that a large proportion of home care clients specifically identified as having rehabilitation potential do not receive it (up to 71%, Hirdes, et al., 2004). In process of developing home care quality indicators using home care assessment data from Ontario and Michigan, Hirdes and colleagues (2004) found that the most frequently triggered quality indicator was ADL rehabilitation potential with no therapies being provided (74.5%). Moreover, substantial disparities in the provision of home care services (Coyte & Young, 1999) and rehabilitation therapies have been found across health regions in Ontario. In Ontario, the province has been

organized by geography into fourteen health regions known as Local Health Integration Networks or LHINs. Matched to the regional organization of the LHINs, there are fourteen Community Care Access Centres (CCACs). These CCACs work as a single entry point for persons who require home care services (as well as other services such as long-term care home placement). Decisions to provide, or not provide, rehabilitation therapy services are made by CCAC case managers.

A paper by Mahomed and colleagues (2004) found large discrepancies in rehabilitation strategies across the Community Care Access Centres (CCACs) in the province. Likewise, recent data analyses by Poss (2010) demonstrated that this inter-regional variation in rehabilitation services has persisted over time. This variation unfortunately indicates that where an older home care client lives may play a significant role on whether or not they receive rehabilitation services, despite the client's actual or perceived need. These results of regional variation are disturbing in a publicly funded health system that is designed around the principles of equity and access.

The need to identify the determinants of rehabilitation therapy service provision to older adults is apparent. Due to an aging population and the associated increase in chronic diseases, disability, and complex conditions, the demand of rehabilitation services across Ontario's continuum of care is expected to rise quickly in the years to come (Landry, Jaglal, Wodchis, Raman, & Cott, 2008). Despite rehabilitation therapy services' relevance to major provincial health initiatives including the Aging at Home Provincial Strategy (LHIN, 2012) and the Alternate Level of Care challenge (Walker, 2011), rehabilitation therapy services have incrementally shifted out of the public system and towards the privately funded sector (Gildiner, 2004; Gordon et al., 2007).



While a number of studies have examined predictors or determinants of home care service utilization (Blomgren, Pekka, Martikainen, Martelin, & Koskinen, 2008; Forbes et al., 2003; Solomon et al., 2003; Lee, Kovner, Mezey & Ko, 2001; Hall & Coyte, 2001; Mitchell, Roos, & Shapiro, 2005; Mitchell, Strain, & Blandford, 2007; Diwan, Berger, & Manns, 1997), few have investigated predictors of rehabilitation therapy services in home care (Mayer-Oakes et al., 1992; Freburger, Homes, & Ku, 2012).

The objective of this study is to identify client characteristics that are most associated with the provision of occupational therapy services and physiotherapy services in the Ontario Home Care System. To achieve this objective, census-level standardized assessment information and provincial home care service utilization data will be utilized. This work is situated within a thesis that utilizes the Cross Industry Standardized Process for Data Mining (CRISP-DM; Chapman et al., 2000).

## **6.2 Methods**

This study is a population-level, cross sectional observational study based on the initial assessment of every long-stay home care client from 2005-2010. To organize fifty-six predictor variables, the Andersen-Newman Framework of Health Services Utilization (Andersen, 1995; Andersen & Newman, 1973) was utilized. This research has also been guided by the results from a qualitative study in Phase 1 (semi-structured interviews with home care stakeholders, Armstrong, Section 3 from thesis) and a data descriptive study in Phase 2 (Armstrong, Section 4 from thesis). The findings of the qualitative study helped to identify predictor variables to be used in the study and influenced the choice of separate target variables (OT and PT are modeled separately). Phase 2 findings identified variables

that might be most predictive and influenced the selection of modeling techniques within this study. Phase 1 and 2 results also inform the interpretation of the predictive models. The Office of Research Ethics at the University of Waterloo provided ethics clearance for the secondary analyses of the anonymized health data.

## **Data Sources**

The interRAI home care assessment instrument, the RAI-HC (or MDS-HC, Morris, et al., 1997) is used to collect comprehensive health and functional information on home care clients in the Canadian province of Ontario and many other jurisdictions (Hirdes, et al., 1999). The RAI-HC is mandated in Ontario for assessment of home care clients who are expected to be long stay (i.e., individuals requiring service for 60 days or more; Hirdes, 2006). Consequently, the provincial RAI-HC data repository can be considered to contain census-level data on long-stay home care clients. The RAI-HC assessment is a comprehensive assessment containing over 300 items including personal items, referral information, cognition, communication/hearing, vision, mood and behaviour, informal support services, physical functioning, continence, disease diagnoses, preventive health measures, nutrition/hydration status, oral health, skin condition, and environmental assessments. Once this information is collected by CCAC case managers, it is used to inform and guide comprehensive care and service planning in community-based settings. RAI-HC items have been shown to have good inter-rater and test-retest reliability (Morris et al, 2000). Data collected in the years 2005 through to 2010 using the RAI-HC instrument will form the core of the data used within this study. As the focus of this project will be on older adults, all home care clients under the age of 65 were excluded from the study. Additionally,

analyses excluded RAI-HC assessments performed on older adults in hospitals for placement purposes.

### **Target Variables**

The target variables (also referred to as dependent variables) for this study are the use of OT and the use of PT service after entering the home care system for the first time. Each individual RAI-HC assessment has been linked to health care service use records from the Ontario Association of Community Care Access Centres (OACCAC). OACCAC provides actual home care service use information for both OT and PT services that have been provided by CCACs. With this linked data, this project has the ability to examine the individual client factors that are associated with OT and PT service provision. For these predictive analyses, rehabilitation therapy service use has been dichotomized to examine client factors that are associated with the provision of service (at least one visit versus no services received). The window of time for service utilization that was examined in this study was 90 days post RAI-HC assessment.

### **Predictor Variables**

The Andersen and Newman Framework of Health Services Utilization (Andersen, 1995; Andersen & Newman, 1973) was used to organize the predictor variables within this study. This framework organizes population characteristics into three broad categories: Predisposing Factors; Enabling Factors; and Need Factors. The Andersen and Newman framework is the most common conceptual framework utilized in health services research (Forbes et al., 2003). Variables were selected based upon their availability in the RAI-HC assessment instrument and through the analyses performed in Phase 1 and Phase 2 of the

CRISP-DM process. A breakdown of all RAI-HC predictor variables examined in this study can be found in Tables 11-16.

Predisposing factors included variables that are thought to influence an individual’s propensity to use services before the need for those services is present. For this study, this category contained sex, age, French as the client’s primary language, and marital status. Age was divided into the following categories: 65-69, 70-74, 75-79, 80-84, 85-89, 90-94, 95-99, and 100+. Sex was dichotomous (Male & Female) as was marital status (married vs. not married) and French speaking (French as primary language vs. other).

**Table 11. RAI-HC Predictor Variables: Predisposing Factors**

Predictors Variables	Description
<b>Sex</b>	Male/Female
<b>Marital Status</b>	Married/Unmarried
<b>French speaking</b>	French primary language/other
<b>Age</b>	>65 in 5 year groupings

Enabling factors are client characteristics that facilitate or inhibit the ease at which services can be obtained. Within this category, this study included living alone, place of residence, caregiver frustration, caregiver distress, and educational level achieved.

Breakdown of the enabling factors can be found in Table 12.

**Table 12. RAI-HC Predictor Variables: Enabling Factors**

Predictors Variables	Description
<b>Living Alone</b>	Living by self at time of RAI-HC
<b>Caregiver Not Satisfied</b>	Primary caregiver is not satisfied with support received
<b>Caregiver Distress</b>	Primary caregiver expresses feelings of distress, anger or depression
<b>Education levels</b>	High school or less/Some College/College graduate/Unknown
<b>Region</b>	CCAC that the client resides within

In previous health service utilization research, need factors typically are the most powerful explanatory factors in predicting health care service utilization (Forbes et al., 2003). Since the RAI-HC is a comprehensive instrument that collects information on clinical characteristics for use in care planning, many domains contained in the instrument are related to need. Due to the large number of need factors within the data, these predictive factors were separated into four categories: (1) interRAI scales, (2) interRAI Clinical Assessment Protocols, (3) ADL and IADL impairments, and (4) disease diagnoses.

### interRAI Scales

From the RAI-HC assessment data, a variety of scales are generated for each individual client. These scales have been developed by the interRAI consortium and are embedded directly into the RAI-HC data system. These scales are designed to summarize client characteristics on a number of different domains and are automatically calculated for each client at completion of the RAI-HC to help case managers assess clinical status and care needs. The following interRAI scales are utilized in this study: (1) the Changes in Health, End-stage disease and Signs and Symptoms (CHESS) score (Hirdes, et al., 2003); (2) the Activities of Daily Living (ADL) self-performance hierarchy scale (Morris, et al., 1999); (3) the Instrumental Activities of Daily Living (IADL) performance scale (Morris, Carpenter, Berg, & Jones, 2000); (4) the Cognitive Performance Scale (CPS; Morris et al., 1994); and (5) the Pain Scale (Fries et al., 2001).

**Table 13.** RAI-HC Predictor Variables: Need Factors – interRAI Scales

Predictor Variables	Description
CPS	Cognitive Performance Scale measuring cognitive impairment
CHESS	Changes in Health, End-stage Disease, Signs and Symptoms Scale measuring health instability
ADL Hierarchy	Activities of daily living scale measuring
IADLCapacity	independence/dependence
Pain Scale	Instrumental activities of daily living scale measuring independence/dependence
	Measures pain intensity and duration

interRAI Clinical Assessment Protocols (CAPs)

The CAPs are generated from the RAI-HC assessment items and are designed to identify problem areas to guide care planning. CAPs cover four broad areas that include functional performance, cognition and mental health, social life, and clinical issues. The goals of care for each CAP vary, but they include possibilities such as resolving the identified problem, reducing the risk of decline, or increasing the potential for improvement. The CAPs aim to link information gathered in the assessment to key factors in a person’s life. For this study, a subset of the newest version of interRAI CAPs were included based upon their potential to impact decisions related to both Occupational Therapy and Physiotherapy. The older version of the CAPs, while in place at the time of the data collection, were not utilized in these analyses. The new CAPs that were used in this study include the Physical Activities Promotion CAP (cPACTIV), Instrumental Activities of Daily Living CAP (cIADL), the Activities of Daily Living CAP (cADL), Home Environment Optimization CAP (cENVIR), Institutional Risk CAP (cRISK), the Falls CAP (cFALLs),

and the Pain CAP (cPAIN). Complete descriptions of these CAPs can be found in the CAP manual which is published by the interRAI organization (Morris et al., 2010). A list of the new CAPs selected for use in this study and their descriptions can be found in Table 14.

**Table 14. RAI-HC Predictor Variables: Need Factors - CAPs**

Predictor Variables	Description
cPACTIV	Physical Activities Promotion CAP
cIADL	Instrumental Activities of Daily Living CAP
cADL – Improve	Activities of Daily Living CAP – Improvement
cADL - Decline	Activities of Daily Living CAP– Decline
cENVIR	Home Environment Optimization CAP
cRISK	Institutional Risk CAP
cFALLs – High	Falls CAP – High risk
cFALLs – Med	Falls CAP – Medium risk
cPAIN – High	Pain CAP – High
cPAIN – Med	Pain CAP - Medium

Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL)

The RAI-HC contains eighteen specific items related to ADLs and IADLs. All of these individual items were included in the analyses. These items capture information about the client’s performance the various domain in the last 7 days for IADLs, and for the last 3 days for ADLs. The ADL and IADL items measures were dichotomized (independent vs. requiring assistance). Table 15 contains the list of ADLs/IADLs and their brief description. For additional information, see RAI-HC form included in the thesis appendices.

**Table 15. RAI-HC Predictor Variables: Need Factors**

Predictors	Description
<b>ADLs</b>	
Bed mobility	Needs assistance with mobility in bed
Transfer	Needs assistance moving to and between surfaces
Home	Needs assistance with moving around within home.
Locomotion	
Outside	Needs assistance with moving around outside of home
Locomotion	
Dressing Upper	Needs assistance with dressing and undressing above waist
Dressing Lower	Needs assistance with dressing and undressing below waist
Eating	Needs assistance with eating
Hygiene	Needs with personal hygiene
Toilet Use	Needs assistance with toileting
Bathing	Needs assistance with bathing
<b>IADLs</b>	
Meal Prep	Needs assistance with preparing meals
Housework	Needs assistance with ordinary housework
Managing Finances	Needs assistance with household expenses
Managing Medications	Needs assistance with medication management
Phone Use	Needs assistance with phone use
Shopping	Needs assistance with shopping for food and household items
Transportation	Needs assessment with traveling with a vehicle

Disease Diagnoses

The final subcategory within the Need Factors group is Disease Diagnoses. In total, eighteen diagnoses were included in the analyses, each of the variables were dichotomous (not present vs. present). These eighteen items capture information on diseases that a doctor



has indicated is present and will affect the client’s status, and requires treatment or symptom management. The proportion of these diseases within the study population can be found listed in Section 4.0 of this dissertation. See Table 16 for a complete list of diagnoses included in the predictive analyses.

**Table 16. RAI-HC Predictor Variables: Need Factors – Disease Diagnoses**

Cerebral vascular Disease	Arthritis
Congestive Heart Failure	Hip Fracture
Coronary Arterial Disease	Fracture (other than hip)
Hypertension	Osteoporosis
Irregular Pulse	Psychiatric Disorder
Peripheral Vascular Disease	Cancer
Alzheimer’s Disease (AD)	Diabetes
Dementia Not AD	COPD/Emphysema/Asthma
Parkinson’s	

### **Data Analysis**

Determinants of service provision were examined using a multistage process including bivariate analyses using logistic regression, and multivariate modeling using multilevel models and the Random forest algorithm. These analyses can be divided into three steps.

#### **(1) Bivariate Analyses**

This step of this analytic process consisted of bivariate analyses of each of the predictor variables with the two target variables using logistic regression. These bivariate analyses will indicate which client factors are most highly associated with service provision and also the direction of their influence (predict the use or non-use of services) on an independent

basis, not controlling for additional client factors. Due to the large size of the data and the issues that this can raise for significance testing (Cohen, 2011), p-values were not utilized within this study. Alternatively, cut offs of odds ratios greater than 1.2 and less than 0.8 were utilized to identify influential predictor variables. Due to research findings in CRISP-DM Phases 1 and 2 of this thesis project that indicated a large impact of region on rehabilitation service provision, a logistic model was created to explore this phenomenon across the 14 CCACs in Ontario. All logistic regression models were performed in SAS version 9.1.3 (Cary, NC) using PROC LOGISTIC.

## **(2) Multilevel Models**

The second phase of these predictive analyses incorporated the application of multilevel logistic modeling. Based upon the hierarchical nature of these data (clients nested within CCACs), and because previous research has indicated that place of residence plays an important role in the provision of rehabilitation services (Mahomed, 2004; Poss, 2010; Armstrong, thesis chapter 3), a multilevel logistic modeling approach was chosen as an appropriate tool for this analysis. These multilevel analyses were performed to achieve the following purposes: (a) to examine the impact of nesting (clients within CCACs) on the provision of OT and PT services, (b) to model the provision of OT/PT by predictor variables organized by the Andersen-Newman framework while accounting for nesting effects, and (c) to create final multivariate models that incorporated the most powerful client level predictors from all three client-level predictor variable categories. To achieve these objectives, models were created using a random intercept multilevel modeling approach to account for the differences in service provision between regions (Luke, 2004) and all client level predictors

were treated as fixed effects. Consistent with other multilevel modeling studies (Murnaghan, Leatherdale, Sihvonen, & Kekki, 2008; Leatherdale, 2010; Hobin et al., 2012), a multistep procedure was utilized. For each both OT and PT, seven multilevel models were created in three steps outlined below.

In the first step, null models were created in order identify the amount of variance due to the nesting effects (clients within CCACs). These null models indicate the amount of variance in OT and PT service provision that can be attributed to the client's CCAC membership. The variance in multilevel logistic models is indicated by a measure known as the intraclass correlation coefficient (ICC; Snijders & Bosker, 1999, pg. 224).

In step two of the multilevel logistic analyses, separate multivariate models were created for each of the predictor variable groupings outlined above, creating ten models in total (five for OT, five for PT). In step 3, a final model was developed for both OT and PT that incorporated the strongest predictive variables from step 2 (odds ratio > 1.2 & odds ratio <0.8). These odds ratio cut-off values are used to identify stronger predictor variables and were based upon similar research in RAI-HC data (Thériault & Guthrie, 2012). Analyses were conducted using SAS version 9.1.3 (Cary, NC) using PROC GLIMMIX. For all multilevel logistic models, odds ratio plots were created and can be found in the appendices.

### (3) **Random forest**

The Random forest algorithm (Breiman, 2001a) was also applied to the data to identify predictors of OT and PT service provision utilizing a novel algorithmic approach (Breiman, 2001b) from the field of data mining and machine learning. The application of this novel analytic approach will allow for some comparison between methods. The Random forest

(RF) algorithm is a relatively new procedure but has become a standard data analysis tool in the area of bioinformatics. The algorithm has been shown to perform well in prediction tasks in the field of medicine (Peng, Chuang, Kang, & Tseng, 2010; Dittman, Khoshgoftaar, Wald, & Napolitano, 2011; Maroco et al., 2011) and it can cope with data that contains a large number of variables, complex interaction structures, and highly correlated variables (Boulesteix, Janitza, Kruppa, & König, 2012). The RF algorithm generates a measure of variable importance, which can be used to rank predictor variables in terms of their predictive value in relation to the target variable. By the nature of the algorithm, this variable importance measure takes into account interactions between predictor variables. All 56 predictor variables used in the previous two steps were examined using the randomForest package in R 2.15.0 (R Development Core Team, 2008). For this study, the Random forest algorithm was used on a random sample of 100,000 clients with a forest size of 200 trees. A sample of the overall population was taken due to software limitations (R was unable to compute Random forest analyses on the full sample). AUC values for the Random Forests were calculated using the ROCR package.

### **6.3 Results**

The sample of long-stay home care clients included assessment and rehabilitation therapy service use information from 299 262 older adults. The majority were female (62.5%) with an average age of 81.1 years. Of these clients, 26.5% received OT services within 3 months of their initial RAI-HC assessment and 21.4% received PT services within 3 months of their initial assessment. A more detailed description of the study population can be found in a previous section of the dissertation (Armstrong, Section 4.0 of thesis).

### **(1) Bivariate Analyses**

Table 17 provides the odds ratios and 95% confidence intervals for the most powerful bivariate client level predictors of receiving OT and PT services provided by the Ontario Home Care System (OR >1.2). For OT, the most powerful predictor of receiving services was the Environment CAP (OR = 2.6, 95% CI = 2.47-2.66) followed by the cIADL CAP (OR=2.0, 95% CI = 1.93-1.99), impairment in bed mobility (OR = 1.9, 95% CI = 1.89-1.99), impairment in transfer (OR=1.9, 95% CI =1.87-1.95), impairment in shopping (OR=1.9, 95% CI = 1.85-1.96), and the falls CAP triggered at the medium risk level (OR=1.8, 95% CI =1.78-1.86). For PT, the top predictor was the IADL CAP, followed by hip fracture, impairment in locomotion outside, impairment in shopping, impairment in housework, and impairment in transfer.

**Table 17.** Top Predictor Variables for Receiving Rehabilitation Therapy Services at the Bivariate Level (Logistic Regression)

Occupational Therapy			Physiotherapy		
Variable	OR	95%CI	Variable	OR	95%CI
cENVIR	2.564	(2.47-2.66)	cIADL	2.807	(2.76-2.86)
cIADL	1.957	(1.93-1.99)	Hip Fracture	2.497	(2.40-2.59)
Bed Mobility	1.942	(1.89-1.99)	Locomotion	2.134	(2.10-2.17)
Transfer	1.911	(1.87-1.95)	Outside		
Shopping	1.904	(1.85-1.96)	Shopping	2.101	(2.03-2.17)
cFALLsmed	1.819	(1.78-1.86)	Housework	2.026	(1.95-2.10)
Locomotion	1.761	(1.73-1.79)	Transfer	2.001	(1.96-2.04)
Outside			Other Fracture	1.973	(1.92-2.03)
cADLdecline	1.730	(1.70-1.76)	Bed Mobility	1.885	(1.84-1.94)
Locomotion in Home	1.724	(1.69-1.76)	Locomotion in Home	1.873	(1.84-1.91)
Parkinson's	1.605	(1.54-1.67)	cADLdecline	1.858	(1.82-1.89)
Dressing – Lower Body	1.561	(1.54-1.59)	cFALLsmed	1.777	(1.74-1.82)
Transport	1.559	(1.53-1.59)	cPAINmed	1.732	(1.69-1.78)
Toilet Use	1.552	(1.52-1.58)	cFALLShigh	1.707	(1.67-1.74)
Housework	1.511	(1.46-1.56)	Dressing – Lower Body	1.699	(1.67-1.73)
Dressing – Upper Body	1.506	(1.48-1.53)	Bathing	1.692	(1.66-1.73)
Bathing	1.498	(1.47-1.53)	Transport	1.668	(1.63-1.70)
cPAINmed	1.444	(1.41-1.48)	cENVIR	1.650	(1.59-1.72)
Eating	1.417	(1.39-1.44)	Congestive Heart Failure	1.560	(1.03-1.09)
Meal Preparation	1.395	(1.37-1.43)	Toilet Use	1.527	(1.50-1.56)
cFALLShigh	1.385	(1.36-1.41)	Parkinson's	1.519	(1.46-1.59)
Personal Hygiene	1.382	(1.36-1.41)	Dressing – Upper Body	1.504	(1.48-1.53)
cRISK	1.370	(1.35-1.39)	Meal Preparation	1.501	(1.47-1.54)
CHES	1.327	(1.32-1.34)	cPAINhigh	1.472	(1.45-1.50)
Cerebral vascular Disease	1.317	(1.29-1.35)	Pain	1.356	(1.34-1.37)
Other Fracture	1.282	(1.25-1.32)	cPACTIV	1.342	(1.32-1.37)
Managing Finances	1.259	(1.24-1.28)	Eating	1.322	(1.30-1.35)
cPACTIV	1.238	(1.22-1.26)	Arthritis	1.318	(1.30-1.34)
			Personal Hygiene	1.296	(1.27-1.32)
			Cerebral vascular Disease	1.287	(1.26-1.32)
			CHES	1.272	(1.26-1.28)

Table 18 contains the most powerful predictors of **not** receiving OT and PT services (OR <0.8). The findings illustrate that both having Alzheimer’s disease (OR = 0.68, 95% CI = 0.66-0.70) and triggering the ADL CAP for improvement (OR = 0.71, 95% CI = 0.69-0.74) are predictive of not receiving OT. For PT, have Alzheimer’s disease (OR = 0.33, 95%CI = 0.32-0.35), triggering the ADL CAP triggered at the improvement level (OR = 0.48, 95% CI = 0.46-0.50), having dementia not AD (OR = 0.53 95% CI = 0.51-0.55), cancer (OR = 0.79, 95% CI = 0.77-0.81), and impairment in phone use (OR = 0.80, 95% CI = 0.78-0.82) all were strong barriers to PT services in home care.

**Table 18.** Top Predictive Variables for Not Receiving Rehabilitation Therapy Services at the Bivariate Level (Logistic Regression)

Occupational Therapy			Physiotherapy		
Variable	OR	95%CI	Variable	OR	95%CI
Alzheimer’s Disease (AD)	0.682	(0.66-0.70)	Alzheimer’s Disease (AD)	0.334	(0.32-0.35)
cADLimprove	0.712	(0.69-0.74)	cADLimprove	0.481	(0.46-0.50)
			Dementia Not AD	0.529	(0.51-0.55)
			Cancer	0.790	(0.77-0.81)
			Phone Use	0.799	(0.78-0.82)

Table 19 contains the results of a logistic regression model that examined CCAC membership. Each of the odds ratios from CCACs 2 through to 14 are relative to CCAC 1. Those residing in CCAC 14 are 3.06 times more likely to receive PT compared to those living within CCAC 1. Home care clients residing in region 9 are much less likely to receive OT compared to those living in CCAC 1 (OR = 0.56, 95% CI = 0.53-0.59). Due to the large

variation of OR across the CCACs for both OT and PT, this result indicates that region is influential in terms of service provision for both OT and PT, and justifies the use of multilevel modeling in the next step.

**Table 19. Examining Variation in Rehabilitation Service Provision Across CCACs**

CCAC	Occupational Therapy		Physiotherapy	
	OR	95%CI	OR	95%CI
<b>1</b>	*Reference*		*Reference*	
<b>2</b>	1.011	(0.97-1.05)	0.894	(0.86-0.93)
<b>3</b>	1.221	(1.17-1.27)	1.696	(1.63-1.77)
<b>4</b>	2.182	(2.08-2.29)	2.136	(2.03-2.25)
<b>5</b>	1.332	(1.27-1.39)	1.922	(1.83-2.02)
<b>6</b>	2.481	(2.40-2.57)	2.667	(2.57-2.77)
<b>7</b>	1.929	(1.85-2.01)	1.449	(1.38-1.52)
<b>8</b>	1.498	(1.43-1.57)	1.855	(1.77-1.94)
<b>9</b>	0.555	(0.53-0.59)	0.889	(0.84-0.94)
<b>10</b>	1.673	(1.57-1.78)	1.558	(1.45-1.67)
<b>11</b>	1.060	(1.01-1.12)	1.123	(1.06-1.19)
<b>12</b>	1.781	(1.71-1.85)	1.616	(1.55-1.69)
<b>13</b>	1.263	(1.21-1.32)	0.917	(0.87-0.96)
<b>14</b>	3.237	(3.11-3.37)	3.066	(2.93-3.21)

\*All OR are in relation to CCAC 1



## **(2) Multilevel Models (MLM)**

This first step in the multilevel modeling process is to produce null models that contain only the CCAC membership to predict outcomes. This step is done to ensure that the data justify the decision to assess the two target variables using multilevel methods. The results of these null models can be used to calculate the intraclass correlation coefficient (ICC). For OT, the ICC was equal to 0.21. This indicates that just over 20% of the variance in OT service provision was due to the client's CCAC. For PT, the ICC was smaller (ICC=0.09) and indicated that 9% of the variance in PT service provision was due to CCAC membership. Because these ICCs are fairly large (1/5 and 1/10 of overall variance can be explained by CCAC), these findings indicate that the use of multilevel logistic models is warranted. The following steps examine the multilevel modeling results for each of the Andersen and Newman groupings of predictor variables.

### MLM - Predisposing Factors

Within the predisposing variables examined in this study, only French Speaking was a particularly strong predictor of PT service provision indicating that for those whose primary language is French, they are less likely to receive PT services compared to those who speak other languages (OR = 0.75, 95% CI = 0.71-0.80). Although not considered as strong predictor variables, the additional variables also indicate trends in service provision. For both OT and PT, older adults tended to receive less service. Females compared to males tended to receive less PT, but more OT. Clients who were married at the time of the assessment were less likely to receive both OT and PT. While the OR of age group is fairly small, the impact of age is underestimated due to the many levels in the variable (9) and

should be considered to be a significant predictor of the rehabilitation therapy services. The results of these models can be found below in Table 20.

**Table 20. Multilevel Model Results – Predisposing Variables**

Fixed Effects	Occupational Therapy		Physiotherapy	
	OR	CI	OR	CI
Age Group	0.96	(0.96-0.97)	0.95	(0.95-0.96)
Sex	0.96	(0.94-0.98)	1.06	(1.04-1.08)
French Speaking	0.95	(0.90-0.97)	0.75	(0.71-0.80)
Married	0.96	(0.95-0.98)	0.83	(0.81-0.85)

MLM - Enabling Factors

Four enabling factors were examined in Step 2. Similar to the predisposing factors, only one variable was highly predictive of the target variables. In this case, having a caregiver in distress increased a client’s odds of receiving OT (OR = 1.37, 95% CI = 1.34-1.409). All other variables were not highly predictive of service provision. The results of the Enabling MLM can be found in Table 21.

**Table 21. Multilevel Model Results – Enabling Variables**

<b>Fixed Effects</b>	<b>Occupational Therapy</b>		<b>Physiotherapy</b>	
	<b>OR</b>	<b>CI</b>	<b>OR</b>	<b>CI</b>
Living Alone	1.06	(1.04-1.08)	0.91	(0.90-0.93)
Caregiver not Satisfied with Support	1.09	(1.03-1.15)	0.88	(0.82-0.94)
Caregiver distress	1.37	(1.34-1.41)	1.00	(0.97-1.03)
Education*				
Unknown	*Reference*		*Reference*	
HS or Less	1.07	(1.07-1.11)	0.95	(0.91-0.98)
University	0.92	(0.89-0.95)	0.87	(0.85-0.90)
Grad Degree	0.93	(0.90-0.97)	0.91	(0.87-0.94)

\*Education OR are in relation to Education = Unknown

Abbreviations: HS = High School; Grad = Graduate

#### MLM - Need Factors

A large number of need factors can be found within the RAI-HC. For these factors, four separate models were created for each target variable and were organized into the following categories: (1) interRAI Scales, (2) interRAI CAPs, (3) ADL/IADL impairments, and (4) disease diagnoses. Within the models containing the interRAI Scales, the CHES score was the strongest predictor of OT (OR = 1.25, 95% CI = 1.244-1.264). For PT, two predictor variables were classified as being strong: (1) the Pain Scale (OR = 1.25, 95% CI = 1.241-1.263) and the Cognitive Performance Scale (CPS, OR = 0.69, 95% CI = 0.680-0.696). The full results for these models can be found in Table 22.

The results of the interRAI CAPs models indicated that for OT, the Home Environment Optimization CAP (cENVIR) was a strong predictor of OT service provision, even after adjusting for all other CAPs. Clients that triggered cENVIR were 2.22 times more likely to receive OT services compared to those who did not trigger cENVIR. Other CAPs

that when triggered, are predictive of OT service provision were the FALLs CAP – Medium Risk (cFALLS – Med, OR = 1.7, 95% CI = 1.655-1.737), the Instrumental Activities of Daily Living CAP (cIADL, OR = 1.69, 95% CI =1.655-1.737), and the Activities of Daily Living CAP triggered at the level of decline (cADL, OR = 1.39, 95% CI =1.359-1.420). For PT, the strongest predictor of service provision was the Instrumental Activities of Daily Living CAP (cIADL, OR = 2.29, 95% CI =2.245-2.335). The PT model also contained a need factor that was strongly associated with not receiving services: Institutional Risk CAP (OR = 0.74, 95% CI = 0.723-0.756). All results for the CAP models can be found in Table 23.

**Table 22.** Multilevel Model Results – Need Factors: interRAI Scales

Fixed Effects	Occupational Therapy		Physiotherapy	
	OR	CI	OR	CI
CPS	0.85	(0.84-0.86)	0.71	(0.70-0.71)
ADL Hierarchy	1.13	(1.12-1.14)	1.17	(1.16-1.18)
IADL Sum	1.04	(1.03-1.05)	1.13	(1.12-1.13)
CHES	1.25	(1.24-1.26)	1.18	(1.17-1.19)
MAPLe	1.15	(1.14-1.16)	1.04	(1.03-1.06)
PAIN	1.11	(1.10-1.11)	1.24	(1.23-1.248)

**Table 23.** Multilevel Model Results – Need Factors: CAPs

Fixed Effects	Occupational Therapy		Physiotherapy	
	OR	CI	OR	CI
cPACTIV	1.14	(1.12-1.17)	1.23	(1.20-1.26)
cIADL	1.69	(1.66-1.72)	2.29	(2.25-2.34)
cADL - Improve	1.08	(1.04-1.12)	1.03	(0.98-1.08)
cADL - Decline	1.39	(1.36-1.42)	1.71	(1.68-1.76)
cENVIR	2.22	(2.13-2.31)	1.24	(1.19-1.30)
cRISK	1.11	(1.09-1.13)	0.74	(0.72-0.76)
cFALLs – High	1.36	(1.34-1.39)	1.74	(1.70-0.18)
cFALLs – Med	1.70	(1.66-1.74)	1.87	(1.82-1.92)
cPAIN – High	1.15	(1.13-1.17)	1.49	(1.46-1.53)
cPAIN – Med	1.36	(1.32-1.40)	1.78	(1.73-1.83)

The results for ADL impairments and disease diagnoses can be found in Table 24 and Table 15, respectively. For OT, the strongest predictor of the ADLs was needing assistance with transfer (OR = 1.51, 95% CI = 1.452-1.579), followed by needing assistance with dressing lower body (OR = 1.24, 95% CI = 1.198-1.281), and needing assistance with bed mobility (OR = 1.23, 95% CI = 1.177-1.285). For PT, a number of difficulties with ADLs and IADLs were predictive of not receiving services, including home locomotion, outside locomotion, dressing upper body, housework, managing medications, phone use, and shopping. Two variables stood out as predictive of receiving services, managing finances (OR = 1.61, 95% CI = 1.556-1.668) and Meal preparation (OR = 1.65, 95% CI = 1.612-1.691). Findings related to ADLs and IADLs can be found in Table 14.

The MLM multivariate results for disease diagnoses can be found in Table 25. The disease found to be most related to OT service provision was cerebrovascular disease (OR = 1.32, 95% CI = 1.293-1.351) and fracture (OR = 1.23, 95% CI = 1.196-1.269). A diagnosis of Alzheimer's disease was predictive of not receiving OT (OR = 0.71, 95% CI = 0.682-0.730). Alzheimer's disease was also related to not receiving PT services (OR = 0.34, 95% CI = 0.320-0.352), as was dementia not Alzheimer's disease (OR = 0.50, 95% CI = 0.486-0.518) and cancer. (OR = 0.82, 95% CI = 0.794-0.837). In terms of predicting provision of PT, hip fracture was by far the strongest predictor (OR = 2.41, 95% CI = 0. 2.313-2.506), followed by Parkinson's disease (OR = 0.82, 95% CI = 1.582-1.731).

Table 24. Multilevel Model Results – Need Factors: ADLs/IADLs

Fixed Effects	Occupational Therapy		Physiotherapy	
	OR	CI	OR	CI
Bed mobility	1.23	(1.18-1.29)	1.14	(1.11-1.18)
Transfer	1.51	(1.45-1.58)	1.36	(1.30-1.42)
Home	1.01	(0.97-1.06)	0.81	(0.79-0.83)
Locomotion				
Outside	1.30	(1.27-1.33)	0.77	(0.75-0.79)
Locomotion				
Dressing Upper	1.01	(0.98-1.05)	0.64	(0.62-0.65)
Dressing Lower	1.24	(1.20-1.28)	1.50	(1.44-1.56)
Eating	0.96	(0.92-1.01)	1.32	(1.29-1.36)
Hygiene	0.93	(0.91-0.96)	1.17	(1.11-1.22)
Toilet Use	0.94	(0.91-0.98)	1.39	(1.33-1.45)
Bathing	1.13	(1.11-1.16)	1.13	(1.08-1.18)
Meal Prep	1.02	(1.00-1.06)	1.65	(1.61-1.69)
Housework	1.02	(0.99-1.07)	0.88	(0.85-0.91)
Managing	1.01	(0.99-1.03)	1.61	(1.56-1.67)
Finances				
Managing	0.94	(0.92-0.96)	0.85	(0.80-0.90)
Medications				
Phone Use	0.85	(0.83-0.87)	0.87	(0.84-0.90)
Shopping	1.44	(1.39-1.49)	0.89	(0.85-0.93)
Transportation	1.20	(1.17-1.23)	1.30	(1.27-1.33)

**Table 25. Multilevel Model Results – Need Factors: Disease Diagnoses**

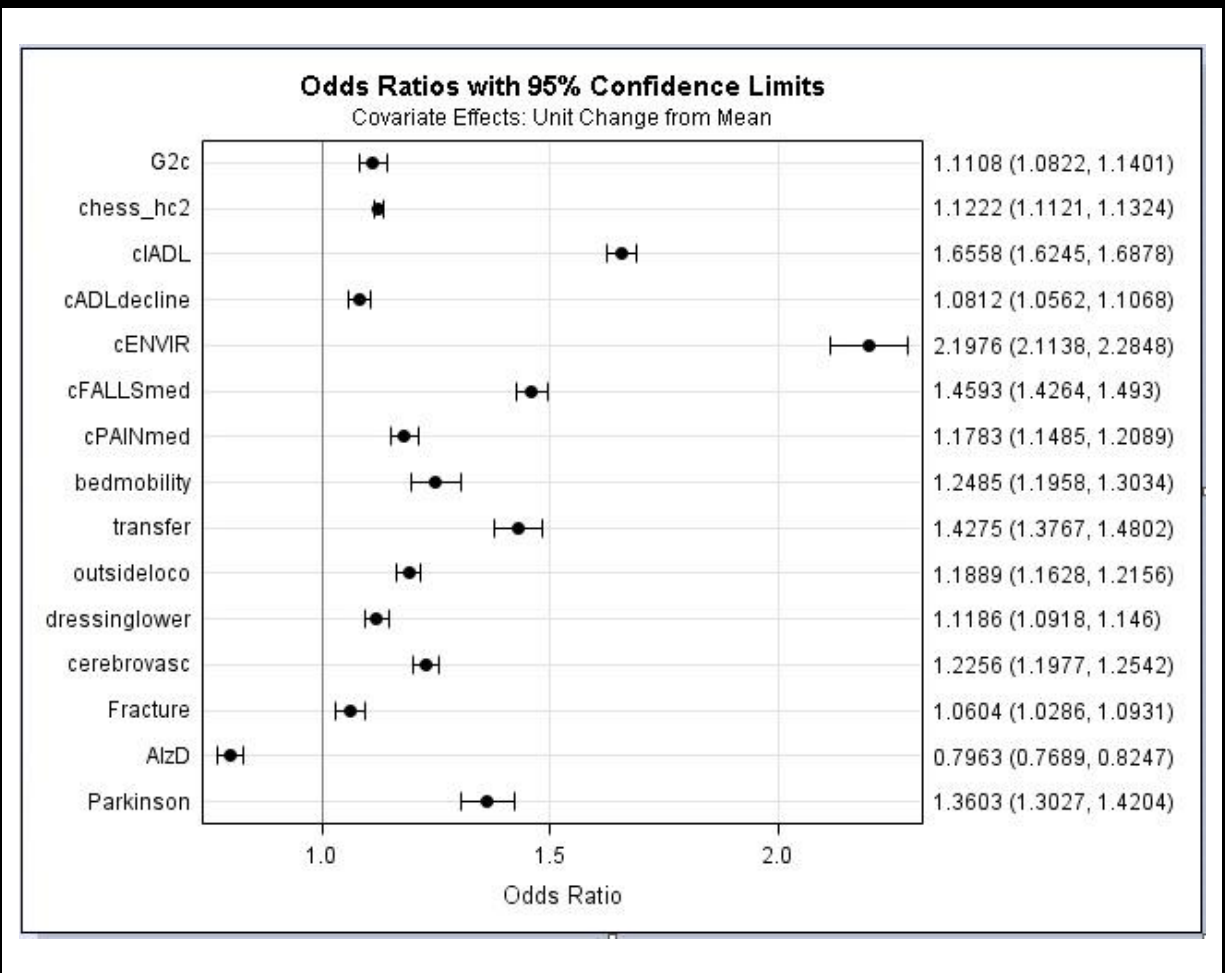
<b>Fixed Effects</b>	<b>Occupational Therapy</b>		<b>Physiotherapy</b>	
	<b>OR</b>	<b>CI</b>	<b>OR</b>	<b>CI</b>
Hypertension	1.04	(1.02-1.05)	1.06	(1.04-1.08)
Arthritis	1.05	(1.03-1.07)	1.19	(1.16-1.21)
Diabetes	1.09	(1.07-1.11)	1.06	(1.04-1.08)
Coronary Artery Disease	1.01	(1.00-1.03)	1.02	(1.00-1.04)
Osteoporosis	1.04	(1.02-1.07)	1.06	(1.03-1.08)
Cancer	0.94	(0.92-0.96)	0.82	(0.79-0.81)
Cerebrovascular Disease	1.32	(1.29-1.35)	1.30	(1.27-1.33)
Congestive Heart Failure	1.06	(1.03-1.09)	0.97	(0.94-1.00)
COPD/Emphysema/Asthma	1.12	(1.10-1.15)	1.05	(1.02-1.07)
Dementia Not AD	0.87	(0.84-0.89)	0.50	(0.49-0.52)
Irregularly Irregular Pulse	1.04	(1.01-1.07)	1.09	(1.06-1.12)
Fracture	1.23	(1.20-1.27)	1.79	(1.74-1.85)
Alzheimer’s Disease	0.71	(0.68-0.73)	0.34	(0.32-0.35)
Peripheral Vascular Disease	1.00	(0.97-1.04)	0.96	(0.92-1.00)
Hip Fracture	0.99	(0.95-1.03)	2.41	(2.31-2.51)
Parkinson’s	1.70	(1.63-1.77)	1.65	(1.58-1.73)
Psych	1.03	(1.00-1.06)	0.94	(0.91-0.97)

MLM - Final Models

The odds ratios for the final predictive models can be found in Figures 21 and 22.

All predictor variables that had an OR > 1.2 or an OR < 0.8 in the multilevel models from Step 2 were included. For OT, cENVIR remained the most predictive variable (OR = 2.20, 95% CI = 2.11-2.28). The top predictor variables for PT provision included hip fracture (OR = 2.07 95% CI = 1.99-2.16), the IADL CAP (OR = 2.01, 95% CI = 1.96-2.05), Alzheimer’s disease (OR = 0.57, 95% CI = 0.54-0.60), and Dementia not Alzheimer’s disease (OR = 0.70, 95% CI = 0.67-0.72). The AUC for the OT model was 0.69, and the AUC for the PT model was 0.74.

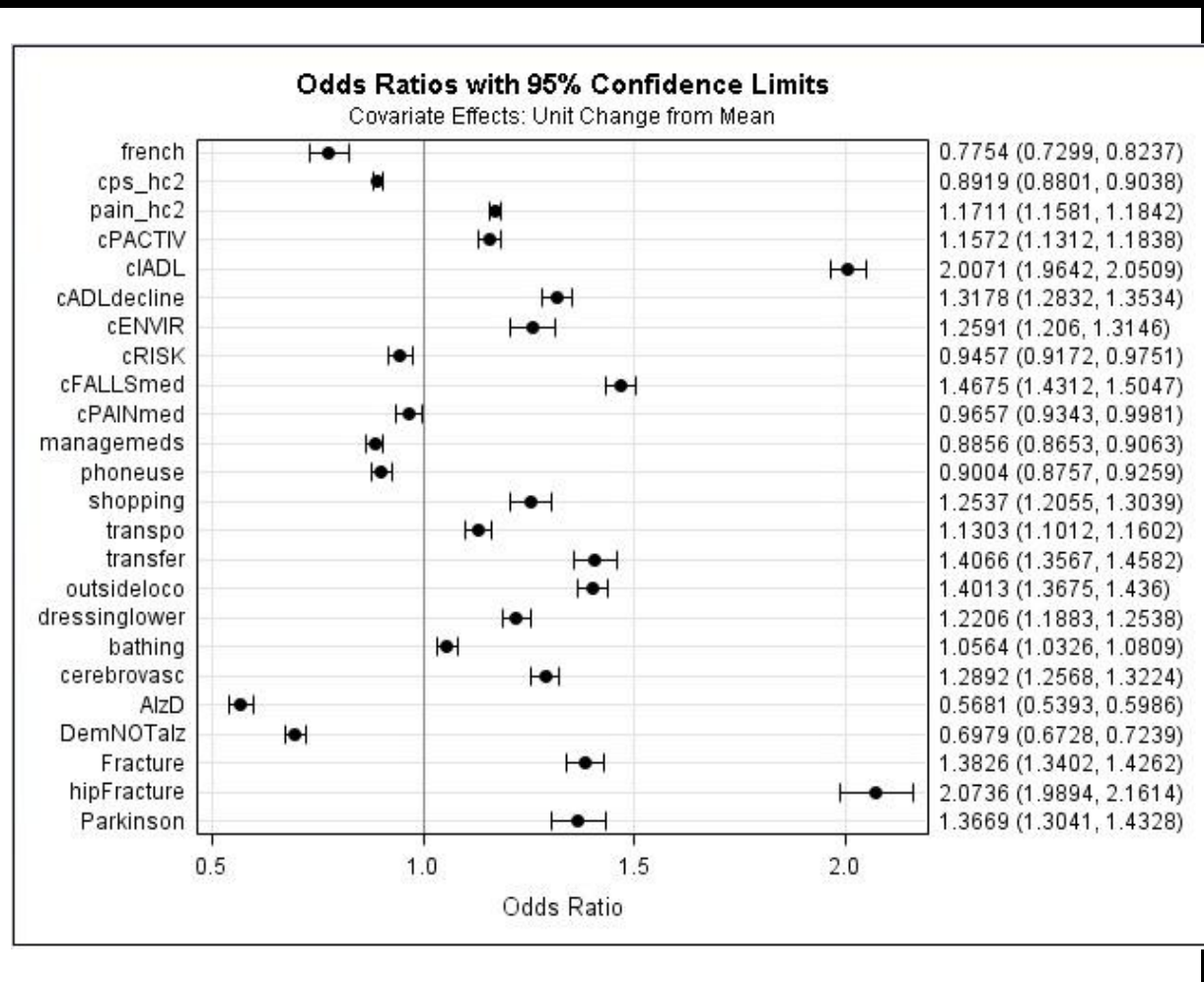
**Figure 21. Odds Ratio Plot – Final Model (OT)**



**Abbreviations:** G2c = caregiver distress, chess\_hc2 = CHESS, cIADL = IADL CAP, cADLdecline = ADL CAP (triggered for decline), cENVIR = Home Environment Optimization CAP, cFALLSmed = Falls CAP (triggered at medium risk), cPAINmed = Pain CAP (triggered at medium level), bedmobility = ADL impairment in bed mobility, transfer = ADL impairment in transfer, outsideloco = ADL impairment in locomotion outside, dressinglower = ADL impairment in dressing lower body, cerebrovasc = cerebrovascular incident, fracture = fracture other than hip fracture, AlzD = Alzheimer’s disease, Parkinson = Parkinson’s disease.



**Figure 22. Odds Ratio Plot – Final Model (PT)**



**Abbreviations:** French = French as primary language, cps\_hc2 = CPS, pain\_hc2 = Pain Scale, cPACTIV = Physical Activities CAP, cIADL = IADL CAP, cADLdecline = ADL CAP (triggered for decline), cENVIR = Home Environment Optimization CAP, cRISK = Risk of Institutionalization CAP, cFALLSmed = Falls CAP (triggered at medium risk), cPAINmed = Pain CAP (triggered at medium level), managemeds = IADL impairment in managing medications, phoneuse = IADL impairment in using the telephone, shopping = IADL impairment in shopping, transpo = IADL impairment in transportation, transfer = ADL impairment in transfer, outsideloco = ADL impairment in locomotion outside, dressinglower = ADL impairment in dressing lower body, bathing = ADL impairment in bathing, cerebrovasc = cerebrovascular incident, AlzD = Alzheimer’s disease, DemNOTalz = dementia not Alzheimer’s disease, fracture = fracture other than hip fracture, hipfracture = hip fracture, Parkinson = Parkinson’s disease.

### (3) Random forest

Table 26 contains the top 15 variables for predicting OT service provision and PT service provision using the variable importance measure from the RF algorithm. For both services, Age is ranked as the top predictor. After age, IADL capacity, education, and the CHES scale are included in the top 4 for both OT and PT, however, not in the same order. These results differ from the variables that were identified in the multilevel modeling steps. These differences indicate that some interactional effects likely exist for predicting both OT and PT, and also further highlights the complexities found when dealing with the health and health service use of older adults. Age as the number one ranked variable indicates that for different age categories, differing characteristics are associated with services provision.

**Table 26.** Top predictors from the Random forest models

Occupational Therapy			Physiotherapy		
Rank	Variable	VI measure	Rank	Variable	VI measure
1	Age	2661.50	1	Age	2200.80
2	IADL Capacity	1922.53	2	CHES	1547.45
3	Education	1764.71	3	IADL Capacity	1533.23
4	CHES	1750.11	4	Education	1479.21
5	CPS	1330.84	5	cIADL	1298.76
6	Pain	1211.66	6	CPS	974.16
7	Hypertension	903.67	7	Pain Scale	874.00
8	Arthritis	880.69	8	Hypertension	732.02
9	ADL Hierarchy	826.33	9	Arthritis	696.67
10	Sex	790.62	10	ADL Hierarchy	684.61
11	Diabetes	776.73	11	Diabetes	662.69
12	Coronary Artery Disease	762.76	12	cPACTIV	660.87
13	cIADL	755.69	13	Coronary Artery Disease	654.09
14	Marital Status	710.31	14	Sex	638.91
15	Osteoporosis	709.17	15	Marital Status	630.61

## **Area Under the Curve**

Area under the curve (AUC) is a common measure used in medicine to evaluate and compare predictive models (Pepe, 2003; Gönen, 2006). If a model can perfectly predict a target variable, their AUC would be equal to 1.0. For this study, the AUC values can be examined across all sixteen models and can be used to indicate which sets of variables and which tools were best at predicting the two target variables using this data. Table 27 contains the AUC values for all models in this study.

When examining the Andersen and Newman variable groupings, the Need Factors were clearly the most predictive sets of variables (note that these models also had the largest number of predictors). Within the Needs Factors, the set of variables that had the highest AUCs for both OT and PT were the CAPS (OT AUC = 0.68; PT AUC = 0.72). For the multilevel logistic models, the highest AUCs came from creating the final models that used the strongest predictors from across all three Andersen-Newman variable categories (OT AUC = 0.69; PT AUC = 0.74). Comparing the results of the MLM with the Random forests, the RF analyses performed comparable to the final multilevel logistic models.

**Table 27. AUC for MLM and RF Models**

<b>Model</b>	<b>Occupational Therapy AUC</b>	<b>Physiotherapy AUC</b>
Predisposing Factors	0.6239	0.6247
Enabling Factors	0.6218	0.6190
Need Factors		
1. Scales	0.6218	0.6897
2. CAPs	0.6792	0.7185
3. ADL/IADL	0.6542	0.6876
4. Disease	0.6264	0.6621
Final Model	0.6897	0.7386
Random Forest	0.6729	0.7248

## 6.4 Discussion

This study has investigated the client level factors that are associated with the provision of OT and PT in a population of older long-stay clients in the Ontario Home Care System. Using three different types of tools, a number of client factors were identified as correlates of the rehabilitation therapy service provision. Predictor variables differed for OT and PT service provision, and variation was found between methodological approaches. The bivariate analyses examining region clearly showed that the region in which the client resides has a large impact on their probability to receive OT and PT services. Odds ratios, when CCACs 2-14 were compared to CCAC 1, ranged from 0.56 to 3.24 for OT, and 0.89 to 3.06 for PT. This clearly illustrates that the provision of both of these therapy services is highly dependent on a client lives.

These regional differences were further illustrated by the ICCs found in the two null multilevel models. These ICCs indicate that for the years 2005-2010, 20% of the variation in the provision of OT can be accounted for by region. For PT, this amount was less but still substantial at 9%. Findings of sizable regional variations in the Ontario Home Care System have been found previously for home care services in general (Coyte & Young, 1999). In a public health care system that is designed to have equal access for all Ontarians across the province, the findings of this study illustrate that equal access to rehabilitation therapy services for older adults may not be occurring for all home care clients across Ontario. These regional variations point towards a need to continuously monitor and modify home care policies and practices to ensure that every older Ontarian has equal access to rehabilitation therapy services, irrespective of where they reside within the province.

These findings also illustrated that one of the main drivers of OT provision was issues with the client's home environment (as measured by Home Environment Optimization CAP). This finding directly coincides with the findings found in the qualitative study in Phase 1 (Armstrong, Section 3.0 of thesis) where it was indicated that OT is mainly used for environmental assessment. The qualitative study also found that OT is utilized for home equipment purposes, which could be related to the finding of this study that bed mobility and transferring were highly predictive of receiving OT.

For PT, the strongest determinants of service provision at the bivariate level were the IADL CAP, hip fracture, trouble with locomotion outside of the home, and shopping. The IADL CAP was designed to identify persons who have the capacity and interest to carry out their IADLs more independently. Although PT is more directly related to ADLs, IADLs may be serving as a proxy for a client's potential to benefit from PT services. Having a hip fracture emerged as the second highest predictor variable. Past research has illustrated that up to one fifth of hip fracture patients become functionally dependent (Jaglal, Sherry, & Schatzker, 1996). Home care PT services play an important role in maximizing the status of patients with a hip fracture after leaving the hospital and returning to the community.

A number of client level predictors were also indicative of not receiving PT services at the bivariate level. For older long-stay clients, those who had a diagnosis of Alzheimer's disease were much less likely to receive PT services compared to those who did not have a diagnosis of Alzheimer's disease (OR = 0.334, CI = 0.319-349). Those with dementia not Alzheimer's disease were also significantly less likely to receive PT services (OR = 0.529, CI = 0.514-0.546). Furthermore, the CPS was indicative of not receiving PT services. This clearly indicates that for older long-stay clients, dementia and cognitive impairment is a

barrier to receiving PT services in the Ontario Home Care System. The results of the Phase 1 qualitative study (Armstrong, Section 3.0 of thesis) and of previous research (Hershkovitz, Kalandariov, Hermush, Weiss, & Brill, 2007) have indicated that cognitive impairment can impact the effectiveness and efficiency of PT in older adults. However, other research has contrastingly indicated that PT can lead to positive outcomes for older adults with cognitive impairments (Naglie et al., 2002; Colombo et al., 2004; Ghisla et al., 2007). With the number of older adults experiencing dementia expected to increase dramatically in Ontario (Alzheimer Society of Canada, 2010), further research is needed to clarify the role that home care PT can play for older adults with cognitive impairment.

The bivariate analyses indicated that when the ADL CAP was triggered for improvement, it was indicative of not receiving OT and PT services. This finding is contrary to the ADL CAP guidelines that specifically indicate that PT and OT should be considered for those who trigger the CAP at this level. Potentially, this finding could be related to how rehabilitation services are used in a reactive way for older adults (as outlined in: Armstrong, Section 3.0 of thesis). This reactive approach to providing services may not be the most effective use of the overall health system's resources; providing OT and/or PT to these older adults in home care may result in savings to the system in the future, while also increasing the quality of life, mobility, and functional abilities of the clients. Having French as your primary language was also related to reduced OT and PT service provision. However, this is most likely due to the fact that many Franco-Ontarians live in the North Eastern CCAC. Much of the North Eastern CCAC is considered rural and access to OT and PT in home care may be limited for all home care clients in the region. More research is needed to further elucidate this finding.

The MLM results indicated that with the exception of age, the predisposing variables found within the RAI-HC are of little predictive value in relation to OT and PT services. In other words, sex, and marriage status were not strong predictors of OT or PT service provision. Age was not identified as a significant factor in the MLM nor the bivariate analyses. The Phase 2 analyses indicated that for those over the age of 90, a much smaller proportion received PT services. The findings of small ORs for age in the multilevel modeling steps is more likely a function of how the information related to age was coded in the analyses (9 separate age groups). The importance of age as a predictor of the therapy services is further discussed in relation to the findings of the Random forest algorithm.

For the enabling factors, after accounting for regional variation, the only strong predictor was caregiver distress for OT services. The need factors within the MLMs produced the most predictive models. These need factor models, after accounting for variation due to the client's location, found that a number of client characteristics remained to have a strong impact on the provision of rehabilitation therapy services. The predictors in the two final models were similar to the findings of the bivariate analyses; however, the strength of the OR had changed in the multivariate models. This indicates that despite variations across regions, similar factors tend to influence the provision rehabilitation services to older home care clients.

The variable importance measures from the Random forest algorithm showed that age, IADL capacity, Education, and CHESS were the top predictors for both OT and PT service provision. These findings differ from the results of the regression analyses illustrating that the Random forest algorithm can be utilized to identify important characteristics that can be missed with traditional statistical modeling methods. These



differences in top predictors can be explained by the way that Random forests are designed using a collection of decision trees, in that interaction effects between the numerous predictor variables are taken into account in the predictions (Boulesteix, Janitza, Kruppa & König, 2012). With age as the top predictor in both the OT and PT Random forest models, there may be differences in how predictors operate for the different age groupings. Similarly, interaction effects for the other top predictors (IADL capacity, Education, and CHESS) are also plausible. Further research is required to fully understand how these client characteristics interact and relate to OT and PT service provision.

The AUCs found with the multilevel models were smallest for the predisposing factors and the enabling factors. This is due to the small number of predictor variables of these categories that could be found within the RAI-HC. For the predisposing and enabling factors that are contained within the RAI-HC, only caregiver distress was found to be highly predictive of OT service provision. Within the needs factors, the group of variables that had the highest AUC for both OT and PT were the models that contained the CAPs.

When all the strongest predictors were used to create the final models, the best AUCs were achieved for both OT and PT service prediction. These AUCs of the final MLMs slightly outperformed the Random forest algorithm that was run using 200 trees per model. However, Random forests do contain tuning parameters (i.e., number of trees per forest, size of the decision trees; Zhu, 2010) and with some adjustment, future research could lead to AUCs for the Random forest that surpass the levels found using multilevel logistic regressions analyses.

. Whereas past research has looked at OT/PT combined (Mayer-Oakes et al., 1992), this study disaggregated the rehabilitation services and created separate predictive models

for each of the services. The choice to proceed with examining the services separately was derived from the Phase 1 qualitative study where the findings indicated that the two rehabilitation services are utilized in completely separate manners. By examining these rehabilitation therapy services separately, while, there was some overlap between in the two final models, the results indicated that different variables influenced the likelihood of receiving a particular service. For example, home environment assessment was found to be the key determinant of OT provision, whereas cognition had a powerful influence of PT. These differences in the predictor variables between the two services indicate that OT and PT are used in the Ontario Home Care System for different purposes and future home care research should continue to examine these rehabilitation services separately.

This study adds to the body of literature that utilizes the Andersen and Newman Model by examining a specific type of home-care service using regularly collected assessment data. The Andersen and Newman Model remains a useful tool that can be used to understand and explain variations in health service use. Similar to the findings of past research on home care utilization, need factors were found to have the strongest association with the use of services (Forbes et al., 2003; Diwan, Berger, & Manns, 1997). However, this current research study found that the enabling factor of region, or where a client resides, can also be important factor in understanding home care service provision in Ontario.

### **Limitations**

There are a number of limitations for the study. First, the sample that was used for the analysis contained only long-stay clients. This client population does not contain the older adults who remained in the home care system for less than sixty days. Although they

were not the focus of this study, many short stay clients receive rehabilitation services. Therefore, the data utilized in this study does not supply enough information for a complete analysis of rehabilitation services for older adults in home care. Currently, a new tool, the interRAI Contact Assessment, is being rolled out across the province. While this tool has fewer data items than the RAI-HC, combining information from the two tools would provide a more complete picture of both short and long-stay clients.

A second limitation of this study is that the analyses were cross sectional and examined service use within a short time period post assessment (window for the target variables was 3 months post RAI-HC assessment). Future research would benefit from examining the use of home care services over the entire time that clients spend in the system. Also related to time, this study did not examine factors that related to changes in the home care system that occurred from 2005-2010. As the home care system (and any health care system for that matter) is dynamic, changes in how the system provides services would have changed to some degree during the study period. Future research studies could be conducted to longitudinally examine how services provision changes over time and the impact that policy decisions have on service provision and client outcomes. A further limitation of this research study was the difference in sample sizes between the multilevel models and the Random forest analyses. The reduced sample used by the Random forest algorithm makes direct comparison between the predictive methods challenging. If after further adjustments within the R software and R scripts/code, the software continues to not be able to handle the full set of data, the multilevel models could be run on the same 100 000 client sample to allow for a direct comparison of the two methods.

Additionally, the Random forest analyses could be approached in a different way then reported within this chapter. The Random forest analyses were conducted to be easily compared to the multilevel models. However, the approach could be altered to a way that is more commonly found in data mining and machine learning analyses. More specifically, the Random forest analyses could be run and parameters adjusted on a training sample (e.g., 2/3 of the data). Once the algorithm has been “trained”, the Random forest could then be tested on a test sample (e.g., the remaining 1/3 of the data). This type of approach will be taken when working towards publishing this work in academic journals.

Within the RAI-HC data system, there is a limited amount of information on predisposing and enabling factors. Because of this, using the Andersen and Newman framework with RAI-HC data is limited to focusing primarily on need factors. Within enabling factors that were included in the study, the usefulness of the education variable and results from it are difficult to interpret due to the fact that for many of these older clients, their education level was collected as “unknown”. Therefore, any interpretation of findings related to this variable requires some caution. A further limitation of this study is that findings of this study relate to decisions that can be made at the provincial level. Although these provincial level findings are important, many important policy decisions are made at the level of the CCAC. Secondary data analysis research may be more useful if it was focused on problems and data from a regional standpoint.

## **Conclusions**

This study provides findings that help increase our understanding of rehabilitation services in the Ontario Home Care System by identifying the main drivers of service provision in the years 2005-2010. The results of this study clearly illustrate that

rehabilitation therapy service provision varies greatly across regions. More research is needed to determine exactly why this is the case, what regional factors could be responsible, and how we can develop strategies to reduce the differences. An important message of this paper for health care policy makers is that despite the fact that this is a public system of home health care, inequities in access exists between regions.

The findings of the regional differences and of the potential interactions effects found by the RF algorithm indicate that for research related to the health of older adults, context matters. Contextual effects, at both the regional and clinical levels, should not simply be controlled for as they often are when using traditional statistical techniques (Luke, 2005). Tools such as multilevel modeling and Random forests, as well as geographic information systems, social network analysis, and cluster analysis, can be useful tools to address contextual effects that can be of significant importance in the health sciences.

These predictive modeling analyses benefitted from the qualitative research performed in Phase 1, and the descriptive study in Phase 2. Firstly, the qualitative study helped the analyses in this chapter by identifying the main research question: what are the drivers of home care rehabilitation therapy provision across the province. From the interviews, the respondents had a detailed understanding of factors related to OT and PT at a clinical level. However, their responses seemed to lack an understanding of these issues at a population level. Secondly, the interviews allowed the researcher to develop an thorough understanding of the OT and PT services, and the way in which decisions to provide rehabilitation therapy services are made by case managers, Additionally, the interviews allowed the researcher to build an understanding of what types of clients and what types of health issues were commonly found in home care clients and the users of home care

rehabilitation therapy services. Overall, these interviews directly influence the planning and the development of the predictive models. Likewise, Phase 2 activities greatly assisted the work in this chapter by familiarizing the analyst with the data, and discovering initial insights into the data and phenomena of interest. These first two phases in the CRISP-DM were vital for the modeling phase as they allowed for a detailed understanding of rehabilitation services for older home care clients which aided in the data preparation that occurred prior to modeling and the interpretation of the results. Developing an understanding prior to modeling data is a necessary and important step within any data mining project.

Various client-level factors were identified as predictors to the provision of rehabilitation therapy services for older adults. By studying these factors at a provincial level, we can work towards policies and practices that make the home care system more efficient, effective, and safe for our aging population. As previous research has indicated, home care client populations are becoming increasingly complex and difficult to manage due to multimorbidity and cognitive impairments (Murtaugh et al., 2009). The results of this current study raise the question in relation to targeting home care services to the correct individuals. In times of fiscal restraints, evidence-based targeting of rehabilitation services is paramount. Is the home care system targeting the correct older adults with appropriate rehabilitation services? Are we utilizing OT services in their full capacity? Should older adults with cognitive impairment receive more, or less, physiotherapy services? These are questions that are not readily answered by using secondary data from past service practices. These questions need to be determined in collaborations between policy makers, practicing

therapists, CCACs, and researchers. These groups will need to work together to determine how the Ontario Home Care System can be optimally designed to serve older adults.

## **7.0 SUMMARY AND GENERAL DISCUSSION**

This dissertation was used to develop knowledge on rehabilitation therapy services provided by the Ontario Home Care System. By using semi-structured interviews with key stakeholders and a large database of electronic health data collected using the provincially mandated RAI-HC information system, this thesis was able to generate a series of findings related to the demographic and clinical characteristics of older long-stay home care clients, and the provision of occupational therapy and physiotherapy. Prior to a discussion of the general implications of the overall project, each of the sections from the thesis will be briefly summarized. The discussion section will conclude with limitations of the overall study and future research opportunities.

### **Thesis Summary**

The Cross Industry Standard Process for Data mining (CRISP-DM; Chapman et al, 2000) was used as an organizational framework for the thesis. This process framework was chosen to provide a guiding structure to the secondary data analyses project and the thesis research was organized into the six phases that are outlined within the CRISP-DM. The Anderson and Newman Framework for Health Services Research guided the thesis conceptually.

Within the first phase of the project, a series of semi-structured interviews with key informants was conducted to build an in-depth understanding of the thesis topic. Participants in this study provided information from three perspectives: Community Care Access Centre (CCAC) case managers, service providers, and policy makers. The analysis of the ten interviews led to the identification of three themes related to rehabilitation service



provision to older adults: drivers of services, challenges, and decision making. A further ten subthemes were identified and the results of this finding were utilized to inform each of the following phases of the study.

The second phase of this study consisted of a descriptive study of the population characteristics and rehabilitation service use data. The RAI-HC provincial data repository contained information on every long-stay home care clients entering the system in the years 2005 to 2010. This clinical assessment information was linked to service use data. This linked database formed the basis of the core of the thesis project. Many of the key characteristics identified through the semi-structure interviews in Phase 1 were examined in relation to the receipt of occupational therapy (OT) and physiotherapy (PT). This ‘data understanding’ phase provided a description of the complexity and range of needs of home care clients, identified large variation in rehabilitation services across the province’s health regions, and found decreased probability of PT service provision to cognitively impaired clients. In addition to building understanding of OT/PT service provision and characteristics of the long-stay home care client population, this phase of the study yielded an enhanced understanding of the data prior to the modeling stage of the thesis project. Following the Phase 1 study, the data to be utilized in the study were thoroughly investigated in the Phase 2 “Data Understanding” activities. This phase consisted of the the initial exploration of the data and a report (Chapter 4) where the important characteristics that were first identified in Phase 1 are outlined. These two phases were important steps that should occur prior to any data mining activities or statistical analysis.

The modeling activities in Phase 4 led to the creation of two separate chapters. The first modeling procedure was the K-means clustering analyses that can be found within

Section 5 of the thesis. These analyses were used to explore and characterize the heterogeneity within the population of rehabilitation service users. Through the use of a data mining algorithm, seven relatively homogeneous subgroups of OT/PT users were identified and profiles were created for illustration purposes. Also developed within Phase 4 were a series of predictive analyses using logistic regression, multilevel logistic regression, and the Random forest algorithm. Models were created to explore the relationship between a large number of population characteristics and the provision of OT and PT, with provision of each service modeled separately. The results of the study illustrated that after accounting for regional variation in service provision, these two rehabilitation therapy services have a range of differing predictor variables.

### **Policy Implications**

The results of this thesis have a number of implications for the delivery of rehabilitation therapy services to older adults in the Ontario Home Care System. Firstly, the results of the qualitative study indicated that typically, older adults with functional difficulties do not receive rehabilitation services in home care unless an acute episode or hospital admission triggers a referral. Even when older adults are provided with rehabilitation services, the focus tends to be on restoring pre-morbid function, and does not address the additional performance challenges they had prior to their acute incident. If the majority of rehabilitation services in home care are being provided to post-acute clients, this suggests that the home care system may be neglecting chronic care needs of older adults. Therefore, there is an opportunity for shifting the home care system towards providing services that proactively address the needs of older clients with chronic health issues. These

propositions are in accordance with two recent policy analyses in Ontario; the Drummond Report (Drummond, 2012) and the Walker Report (Walker, 2011). These two documents call for a shift to occur within the Ontario Health Care System where helping the functionally vulnerable older adults becomes a priority. Although it is clear that rehabilitation services can assist in this area, there currently are not enough resources within home care to deal with the large amount of rehabilitation needs of older adults (Armstrong, Section 3.0 of thesis). There are two clear ways that this challenge can be dealt with. Firstly, funding for the home care system could be increased. Secondly, rehabilitation services in home care could make the daily functioning of older adults a greater priority, including the early identification of seniors at risk of frailty, and proactive management of their multiple health challenges. Physiotherapists and occupational therapists can have an important role to play in proactive management strategies related to frailty. Current policy initiatives in Ontario at the provincial level (e.g., “assess and restore philosophy”; Walker, 2011) and regional level (e.g., Waterloo Wellington Local Health Integration Network (WWLHIN) Rehabilitation Services Review; WWLHIN, 2012) may address this shift in focus.

Directly related to the identification of at risk clients and targeting of services, the qualitative study within Phase 1 also found that CCAC case managers are interested in the development of new decision support mechanisms. Currently, a variety of decision support algorithms related to functional status (especially the CAPs) have been built into the RAI-HC system. However, key informants clearly indicated that these mechanisms are not currently well utilized in the decision making process. This implies there is an opportunity for knowledge translation and education efforts to support for effective use of the CAPS, as

well as additional research on decision support tools that may have greater utility, are more specific to rehabilitation services for older adults in home care, and are designed in accordance with the provincial/regional initiatives. The interview respondents pointed to the need for decision support approaches that are more in keeping with the resource constraints they face. These concerns may have been more relevant for the prior version of the CAPs; the quantitative results of this study suggest that decision-making in providing rehabilitation services may be more consistent with the new CAPs than is acknowledged by clinicians.

Section 5 identified homogeneous subgroups of rehabilitation clients based upon thirty seven variables found within the RAI-HC. Despite some confirmation of these clusters using one year outcome data, these clusters should be considered exploratory. However, the results highlight the heterogeneity and multidimensionality involved with home care clients. Refining segmentation approaches for older clients could result in the development of more specific planning protocols and also potentially assist in resource allocation decisions. The development of such protocols could also be informed by the analysis of predictors of rehabilitation use.

Within this thesis, it was found within the data that the provision of rehabilitation therapy services varies greatly from region to region in the province. For OT, twenty percent of the variation in service provision could be attributed to the CCAC region in which the client resided. For PT, the amount of variation explained by CCAC was nine percent. These findings indicate that access to rehabilitation in home care is not equal across the province. Additional research is needed to investigate the degree to which these inequities may be offset by availability of other rehabilitation services (e.g., through the Ontario Health Insurance Plan), and to identify other strategies to facilitate more equitable access.

Within the qualitative study, it was found that OT is primarily being used for home assessments and equipment needs, while PT is primarily being used for post-acute episodes (e.g., total knee replacement). The stakeholders interviewed in this study indicated that these rehabilitation services were not being utilized in their traditional ways, or to their full potential. Consequently, there is room for expansion of the role that occupational therapists and physiotherapists perform for older adults in the home care system.

According to the Drummond report, the Ontario Health Care system needs to undergo a broad transformation to meet the needs of a growing population of older adults (Drummond, 2011). Through Sections 4, 5, and 6 of this thesis, predisposing factors, enabling factors, and need factors of older long-stay home care clients were explored. Together, the findings clearly illustrated that older home care clients form a heterogeneous population with a wide variety of impairments, diseases, and service needs. Research that uses traditional statistical approaches such as averages and variable-by-variable analyses may be inadequate to understand the needs of this aging population due to complexities of aging including multimorbidity, cognitive impairment, and the non-linear characteristics of the health, healthcare, and well-being of older adults. To gain deeper insights into the complexities of the aging population, non-linear functions and inter-relationships need to be explored using suitable quantitative and qualitative research tools.

### **Research Implications**

The home care sector is a relatively new and under-researched component of the health care system. As Ontario and other jurisdictions work to transform the system to meet the needs of an aging population, researchers have the opportunity to utilize a range of novel

tools that have been recently developed within fields outside of the health sciences. This thesis demonstrated the application of three of these approaches: K-means cluster analysis, multilevel logistic regression, and Random forest. With quickly expanding databases of health information, innovative quantitative approaches and decision-making algorithms from the field of data mining and machine learning could be developed for use within electronic home health care data repositories.

This thesis highlights the usefulness of routinely collected, standardized data in health care services research. These data allow for an enriched understanding of the use of home care services and can be used to provide practical information for policy development, program planning, management, and evaluation. These data also allow for the monitoring of services and client populations from across the province, and can be used in provincial and international comparisons.

This thesis project utilized a qualitative research process within a knowledge discovery in databases process. Applying qualitative research methods within a knowledge discovery in databases project is novel as no similar examples could be found in the literature. The interviews allowed the researcher to develop an in-depth understanding of the key factors related to rehabilitation services in the home care system that enriched the quantitative analyses of the RAI-HC data and impacted the research project in a number of ways. Firstly, the qualitative work clearly indicated that occupational therapy (OT) and physiotherapy (PT) are utilized differently within the home care system. Therefore, when looking at determinants of service use, it was important to disaggregate the rehabilitation therapy services and look at OT and PT separately. Secondly, the qualitative research provided input into which client characteristics should be examined. Key informants clearly

indicated a number of aspects that are related to service provision and quantitative analyses were able to confirm some of these findings. The qualitative research project also was also of great assistance in the evaluation and interpretation within the modeling phase of the project.

## **Limitations**

This thesis project has a number of limitations. While the focus of the thesis was on older long-stay clients, many older adults who receive OT and PT do not remain in the home care system long enough to be considered long-stay and receive a RAI-HC assessment. Therefore, these analyses cannot be generalized across all home care clients. While long-stay clients are an important population to study, for a complete analysis of rehabilitation in home care, studies would have to include all short-stay clients in addition to the long-stay clients. Within the near future, research spanning the entire home care client population will be possible. A new assessment tool from the interRAI consortium called the Contact Assessment has been recently rolled out in the province for use with short-stay clients. Combining Contact Assessment information and RAI-HC assessment information will provide researchers with information on all home care clients in the province.

Another important limitation is that the research was only able to examine services provided directly through the CCACs. Any rehabilitation therapies that were provided through private payments by the clients, or through their own personal insurance plans, were not recorded within the analysed data. Therefore, although the focus of the thesis was on OT and PT services for home care clients, this study lacked information on total rehabilitation service utilization. As the thesis was aimed at understanding rehabilitation services provided

by CCACs, this does not greatly impact the findings of this research. However, this must be taken into account for interpreting the results comparing users with non-users. More importantly, this limitation should be considered in any future research that aims to evaluate the effectiveness of services (as comparison groups of non-users might actually contain some users of outside services).

The analyses within this thesis utilized data from the years 2005-2010. This time frame in which the data were collected leads to a number of limitations that are worth mentioning. Firstly, the findings of this thesis relates to data that, in terms of the home care system, could be considered as old. The home care system is dynamic and due to this, much of the data relate to policies and practices that may have changed since these data were collected. For example, many of the CCACs are now deploying a new client care model, which changes the organization of case manager caseloads and the care intensity through the development of client population groupings (Complex, Chronic, Community, Independence, Short-Stay and Well; WWCCAC, 2012).

A final limitation to be discussed revolves around the use of rehabilitation therapy terms used in all phases of this thesis project. From the qualitative study to the data description and the data modeling, the term impairment was used with regards to disabilities in activities of daily living and instrumental activities of daily living. This use of the term 'impairment' does not match the International Classification of Functioning Framework (ICF; World Health Organization, 2001). Within the ICF multidimensional framework, impairments occur within body structures/functions, which lead to activity limitations (e.g. ADLs), which in turn impacts participation in social functioning (United Nations Economic and Social Commission for Asia and the Pacific, 2012). All of which are dimensions of



disability. Therefore, the term ‘impairment’ was improperly used as a substitute for ‘disability’ within both the interviews and within the write up of the quantitative analyses. Using the ICF framework and applying it throughout the entire six phases of the project would have been ideal. In particular, the interviews with the ten key informants would have benefited from more detailed discussion regarding how “function” was being defined and how impairment in certain body functions is commonly related to activity limitations in older adults. Additional discussion of the definitions of ‘function’, ‘impairment’, and ‘disability’ with each of the interviewees would have led to a more detailed ‘business understanding’ that matched more closely with the generally accepted ICF framework and an enhanced appreciation of the continuum and the context dependent nature of disability. Overall, using the ICF framework throughout the entire research process would have led to more appropriate conceptualizations of the characteristics of the rehabilitation therapy clients and the findings of the four research studies may have differed slightly as a result.

### **Future Research Directions**

As the strength of regional differences indicate, it will be important for future research using the provincial RAI-HC data repository to consider the potential impact of the hierarchical nature of the provincial home care system. This can be done by examining the different regions independently, or through the use of multilevel modeling techniques. For the multilevel logistic models developed in this thesis, a random intercept approach was taken. Random intercept models are relatively simple to develop and can be used to control for differences between regions within hierarchical organized datasets. Future research could take the multilevel approach further by linking the RAI-HC client level data with

regional data from sources such as Statistics Canada, Canadian Institute for Health Information, or through aggregated RAI-HC client data. By incorporating regional data, a better understanding of context is possible as complex multilevel models can be developed to examine interactions between client level characteristics and regional characteristics. Interactions between client-level and regional variables could be explored through the development of random intercept and random slope models in hierarchical datasets (RAI-HC linked to regional data). For rehabilitation therapy services, the findings of the qualitative study (Section 3.0 of thesis) indicated that regional human resources (e.g., # of PT/OTs in region) and percentage rural are CCAC characteristics that may impact rehabilitation service provision. Related to regional differences, the significant variations in rehabilitation therapy service provision that were found across the fourteen CCACs were alarming and deserve further examination. Factors such as service availability, the availability of outpatient clinics, population characteristics, and other factors may account for some of these differences. However, the differences across the regions were significantly large and future research is needed to examine exactly what factors play a role in these regional differences. This type of research would be useful in assisting policy makers and managers develop their understanding of the phenomenon and work could be done to reduce the differences from occurring across the health regions in Ontario.

Recently, CCACs across Ontario have shifted the way they manage their client populations towards a new approach, the Client Care Model, where clients are classified based upon their level of need. Within this case management model, case management intensity differs based upon the care needs of the client. Future research using the RAI-HC

could evaluate the impact of this shift in management strategy to see its impact on the therapy services that are provided to older adults and the associated health outcomes.

As indicated earlier, there is a need for the development of new decision support mechanisms that directly relate to home care rehabilitation services. These algorithms should have multiple levels so that they could be used to identify and prioritize older clients based upon their need for OT or for PT. Research studies have demonstrated that intervention programs that involve OT and PT are most effective for seniors whose frailty levels are within the mild to medium range (Gill et al., 2003; Faber et al., 2006; Gitlin et al., 2009). Therefore, the development of new rehabilitation algorithms should be constructed with the client's frailty level in mind. Within the RAI-HC data system, frailty status is typically measured by the CHES (Hirdes, Frijters, & Teare, 2003); however, other measures of frailty have also been applied within the RAI-HC data system including the Frailty Index and the Edmonton Frail Scale (Armstrong, Stolee, Hirdes, & Poss, 2010). Using measures of frailty could lead to important findings related to the effectiveness and efficiency of home care rehabilitation services for older adults in Ontario.

Future research in this area should also begin to investigate the impact of multimorbidity (two or more concurrent diseases) on service use and related health outcomes. Based upon the 2005-2010 data cut, 83% of older home care clients had two or more diseases diagnoses. The study of multimorbidity is still in its infancy (Britt, 2008), especially in its relationship to specific health services and health outcomes related to geriatric interventions. When multimorbidity is included in health services research, analyses typically rely on a count of the number of comorbidities, such as the Charlson index. While using this type of approach is a good place to start, disease count indexes do not address the

possible interactions between diseases and the resulting common patterns. Certain disease patterns may impact the use and effectiveness of health services. With clinical and administrative data growing at a rapid rate through the use of standardized information systems and mandated assessment instruments, the application of novel data mining techniques may be helpful in trying to uncover patterns of multimorbidity. One technique that clearly has potential for application in this area is association rule mining (ARM). ARM was developed by Rakesh Agrawal in the 1990s (Agrawal et al., 1993) and the technique can be used to discover association and correlations among items in large databases (Han & Kamber, 2006). Future research could apply this approach to discover the interrelationships between chronic disease and subsequent service use and health outcomes.

Research is also needed in the area of physiotherapy for home care clients with cognitive impairment. The provincial database of RAI-HC assessments indicated that older home care clients with cognitive impairment are much less likely to receive services from a physiotherapist, despite research that has indicated positive effects of physiotherapy for older adults with cognitive impairments (Naglie et al., 2002; Colombo et al., 2004; Ghisla et al., 2007). There is potential for RAI-HC data to be used to identify which type of clients with cognitive impairments benefit most from rehabilitation services provided within the home care system.

A further potential research direction would be to examine clients who did not receive rehabilitation therapy services. The analyses within this thesis project focused on clients who did receive OT and/or PT. However, as previous research has indicated, many home care clients who could benefit from rehabilitation therapy services do not receive it (Hirdes, et al., 2004). Therefore, future research could use RAI-HC data to examine the

population of clients that did not receive OT and/or PT in order to determine what types of home care clients typically do not receive these therapy services. This type of information may identify types of clients who are systematically not receiving services despite their potential to benefit.

This thesis focused on modeling the receipt of therapy services as a binary variable (any vs. no receipt of services). Future research could focus on the amount of service provision (e.g., number of service visits) provided to different types of older clients. This could lead to a better understanding of the relationship between client characteristics, the amount of service provided, and health outcomes of clients. Modeling this type of information can be difficult due to the distributional properties of service provision. For rehabilitation therapy services, the distribution of services tends to follow a Poisson distribution with many clients receiving no visits, most clients receiving 1-4 visits, and few clients receiving 5+ visits. The Poisson distribution needs to be considered when developing models; standard linear regression methods would not be appropriate. The modeling of the number of services can be further complicated by the set number of service visits given to certain care paths (reasons for referral), which can differ from region to region, making provincial analyses and interpretation of results challenging. However, despite these issues, it will be important for future research to examine the effectiveness of services in relation to the number of service visits provided to older home care clients.

Overall, the findings of this research project, in collaboration with input from the Ministry of Health and Long-term Care and the LHINs/CCACs, could be used to develop a method to identify and prioritize home care clients of varying need of rehabilitation therapy services. While the findings of this thesis are useful in understanding rehabilitation therapy

services that have been provided in the past to older clients, the data alone are not able to answer who would benefit most from receiving home care rehabilitation therapy services.

This type of question can only be answered by working in collaboration with CCAC/LHIN managers, policy makers, and rehabilitation professionals, and in consideration of the health care system as a whole.

## **Conclusion**

This thesis has examined the provision of occupational therapy and physiotherapy to older adults within the Ontario Home Care System. The work has developed understanding of the rehabilitation therapy services in home care and of the client population through both qualitative and quantitative approaches within a knowledge discovery in databases process framework. As indicated by the CRISP-DM process model, the results of this work should not simply end in the deployment of the findings (e.g., publications, presentations at academic conferences). The findings of this thesis should also lead back into the development of 'business understanding', acting as a new base for further research using the RAI-HC data repository. As the home care system is a relatively new sector and is currently facing a changing and growing client population, knowledge discoveries using the routinely collected electronic health data have the potential to provide an evidence-base for health system improvement.

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## Appendix 1 – Interview Guide

### Introduction

Thank you for agreeing to participate in this research project. The overall purpose of this dissertation project is to enhance understanding of the provision of rehabilitation services in the Ontario Home Care System. Interviews are being conducted with key informants to gain varying perspectives that can be used to inform the analysis of a large provincial data repository.

This interview will consist of a discussion on rehabilitation service provision in home care and will be guided using the open-ended questions found in the table below. These questions have been organized into three sections based upon the Andersen and Newman Framework of Health Services Utilization. The interview will last approximately one hour and will be tape recorded for transcription purposes. All discussion will be anonymized and your participation is greatly appreciated.

Organized by the Andersen and Newman Framework	Open Ended Questions
<b>Need Factors</b>	<ul style="list-style-type: none"> <li>• Who are the clients that receive rehabilitation services in home care (PT/OT)?</li> <li>• Are there clients who could benefit from rehabilitation services but don't receive them? If so, whom?</li> </ul>
<b>Enabling Factors</b>	<ul style="list-style-type: none"> <li>• Describe how the provision of OT and PT services is decided for home care clients?</li> <li>• What kinds of health care system factors impact the provision of rehabilitation services?</li> </ul>
<b>Predisposing Factors</b>	<ul style="list-style-type: none"> <li>• Do factors such as age and gender impact the decision to allocate PT/OT?</li> <li>• Similarly, do factors such as ethnicity, culture, occupation, and education level taken into account when deciding on services?</li> </ul>
<b>Additional Questions</b>	<ul style="list-style-type: none"> <li>• Do you use the RAI-HC data in your work? CAPS? Outcome measures? (e.g., MAPLe, RAI score, CPS, DRS, CHESS). Why or why not?</li> <li>• What type of information would assist you in your decision making?</li> </ul>



## Appendix 2 –Recruitment Email for Semi-structured Interviews

Subject: Research Study - Rehabilitation Services in Home Care

Hello \_\_\_\_\_ ,

My name is Joshua Armstrong and I am a PhD student in the School of Public Health and Health System at the University of Waterloo. I am currently conducting a research project on the use of rehabilitation services in the Ontario Home Care System under the supervision of Dr. Paul Stolee.

The overall objective of this research study is to enhance our understanding of the utilization and provision of rehabilitation services (occupational therapy and physiotherapy) for older adults. To achieve this goal, I will be conducting both qualitative research and quantitative research. The qualitative component consists of interviewing 10-15 key informants from various perspectives (CCAC case managers, service providers, Ontario system level). The results of the interview stage will be used to inform and guide quantitative analyses using a large provincial data repository of home care assessments.

I have contacted you as I would like to invite you to be a participant for the qualitative component of this project. If you choose to participate in this study, arrangements will be made for a confidential interview at a time and place that is convenient to you. The interview will be focused on rehabilitation services in home care and will last approximately 45 minutes to 60 minutes. Each interview will be digitally recorded.

If you are interested in participating in this study, please contact me at your earliest convenience. I would like to assure you that this study has been reviewed and received ethics clearance through the Office of Research Ethics at the University of Waterloo. However, the final decision about participation is yours.

Thank you for your time. Yours truly,

Joshua J. Armstrong

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## Appendix 3 –Information Consent Letter

University of Waterloo

Date

Dear (*insert participant's name*):

This letter is an invitation to consider participating in a study I am conducting as part of my PhD degree in the School of Public Health and Health Systems at the University of Waterloo under the supervision of Associate Professor Paul Stolee. I would like to provide you with more information about this project and what your involvement would entail if you decide to take part.

The overall objective of this research study is to enhance our understanding of the utilization and provision of rehabilitation services (occupational therapy and physiotherapy) for older adults. To achieve this goal, I will be conducting both qualitative research and quantitative research. The qualitative component consists of interviewing 10-15 key informants from various perspectives. The results of which will be used to inform and guide quantitative analyses using a large provincial data repository of home care assessments.

I have contacted you as I would like to invite you to be a participant for the qualitative component of this project. If you choose to participate in this study, arrangements will be made for a confidential interview at a time and place that is convenient to you.

Participation in this study is voluntary. The interview will be focused on rehabilitation services in the Ontario home care system and will last approximately 45 minutes to 60 minutes. You may decline to answer any of the interview questions if you so wish. Further, you may decide to withdraw from this study at any time without any negative consequences by advising the researcher. With your permission, the interview will be audio recorded to facilitate collection of information, and later transcribed for analysis.

Shortly after the interview has been completed, I will send you a copy of the transcript to give you an opportunity to confirm the accuracy of our conversation and to add or clarify any points that you wish. All information you provide is considered completely confidential. Your name or any identifying information that could identify you (e.g., position title or name of your organization) will not appear within the thesis document or any report resulting from this study; however, with your permission anonymous quotations may be used. Data collected during this study will be retained for 5 years in a locked office in the School of Public Health and Health Systems. Only researchers associated with this project will have access. There are no known or anticipated risks to you as a participant in this study.

If you have any questions regarding this study, or would like additional information to assist you in reaching a decision about participation, please contact me at 519-888-4567 ext. 38982 or by email at [j8armstr@uwaterloo.ca](mailto:j8armstr@uwaterloo.ca). You can also contact my supervisor, Associate Professor *Paul Stolee* at 519-888-4567 ext. 35879 or email at [stolee@uwaterloo.ca](mailto:stolee@uwaterloo.ca).

I would like to assure you that this study has been reviewed and received ethics clearance through the Office of Research Ethics at the University of Waterloo. However, the final decision about participation is yours. If you have any comments or concerns resulting from your participation in this study, please contact Dr. Susan Sykes of this office at 519-888-4567 Ext. 36005 or [ssykes@uwaterloo.ca](mailto:ssykes@uwaterloo.ca).

I hope that the results of my study will be of benefit to those organizations directly involved in the study, older adults who require home health care services, as well as to the broader research community.

I very much look forward to speaking with you and thank you in advance for your assistance in this project.

Yours Sincerely,

Joshua Armstrong

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## Appendix 4 –Feedback Letter To Participants

Department Letterhead

University of Waterloo

Date

Dear (*Insert Name of Participant*),

I would like to thank you for your participation in this study entitled “Rehabilitation Services in the Ontario Home Care System: Conditions of Provision and Utilization”. As a reminder, the purpose of this dissertation project is two-fold:

- (1) To uncover patterns and trends related of rehabilitation service utilization/provision and functional outcomes at individual and LHIN levels using a provincial data repository;
- (2) To improve decision makers’ understanding of the older long-stay home care client population through systematic descriptive analyses and data visualizations of data collected on the system over a period of five years.

The data collected during interviews will contribute to a better understanding of rehabilitation services for older adults in the home care system. The data collected during interviews will guide the analyses of a large administrative data and will be extremely useful in transforming the data into system knowledge.

Please remember that any data pertaining to you as an individual participant will be kept confidential. Once all the data are collected and analyzed for this project, I plan on sharing this information with the research community through seminars, conferences, presentations, and journal articles. If you are interested in receiving more information regarding the results of this study, or would like a summary of the results, please provide your email address, and when the study is completed, anticipated by August 31<sup>st</sup>, 2012, I will send you the information.

In the meantime, if you have any questions about the study, please do not hesitate to contact me by email or telephone as noted below. As with all University of Waterloo projects involving human participants, this project was reviewed by, and received ethics clearance

through, the Office of Research Ethics at the University of Waterloo. Should you have any comments or concerns resulting from your participation in this study, please contact Dr. Susan Sykes, Director, Office of Research Ethics at 519-888-4567, Ext., 36005 or [ssykes@uwaterloo.ca](mailto:ssykes@uwaterloo.ca).

Yours truly,

Joshua Armstrong

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## Appendix 5 – Additional Outputs from Section 5.0

**Figure 23.** Cubic Clustering Criterion Plot for determining K in K-means Analyses

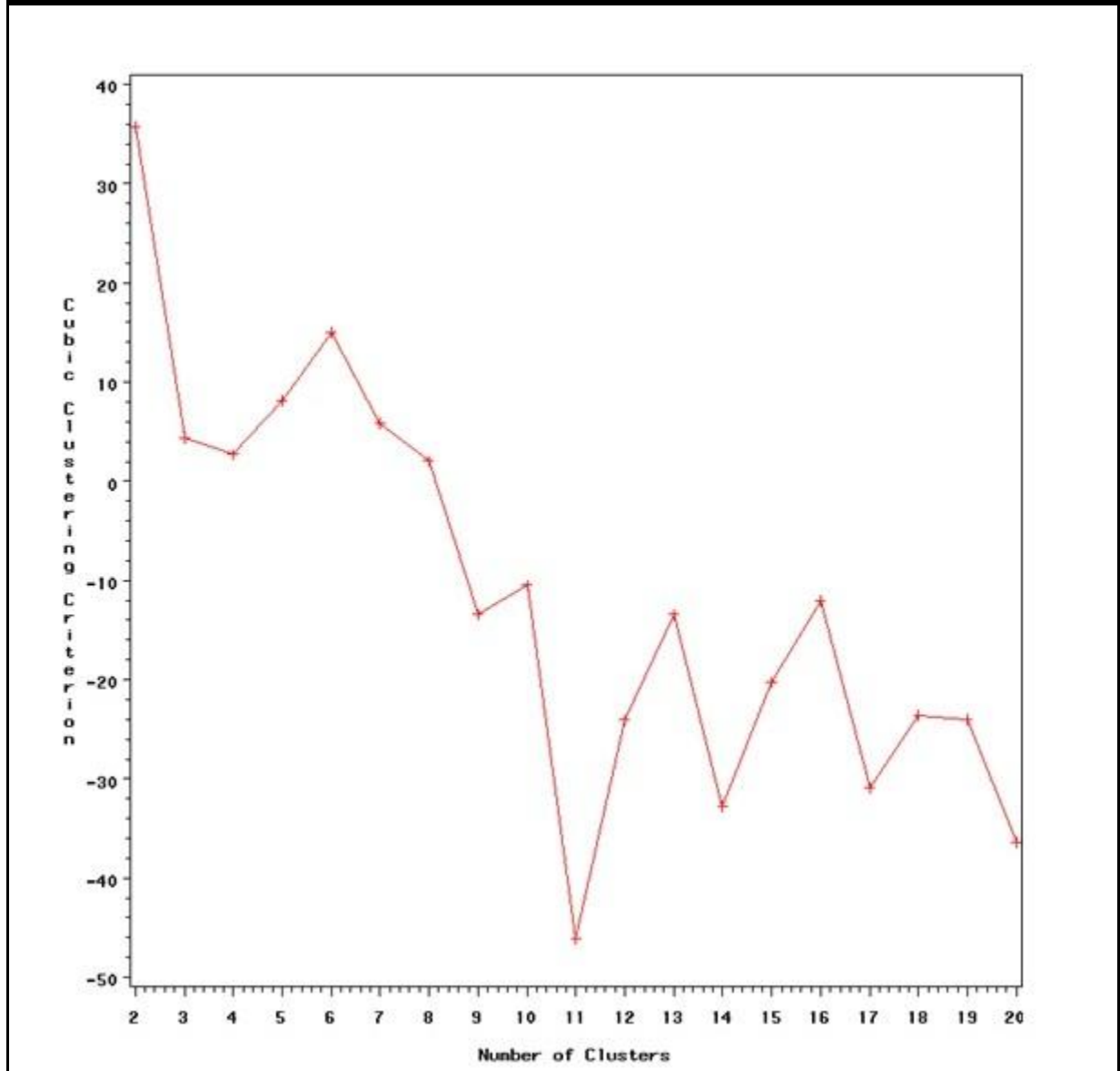


Figure 24. Pseudo-F Plot for determining K in K-means Analyses

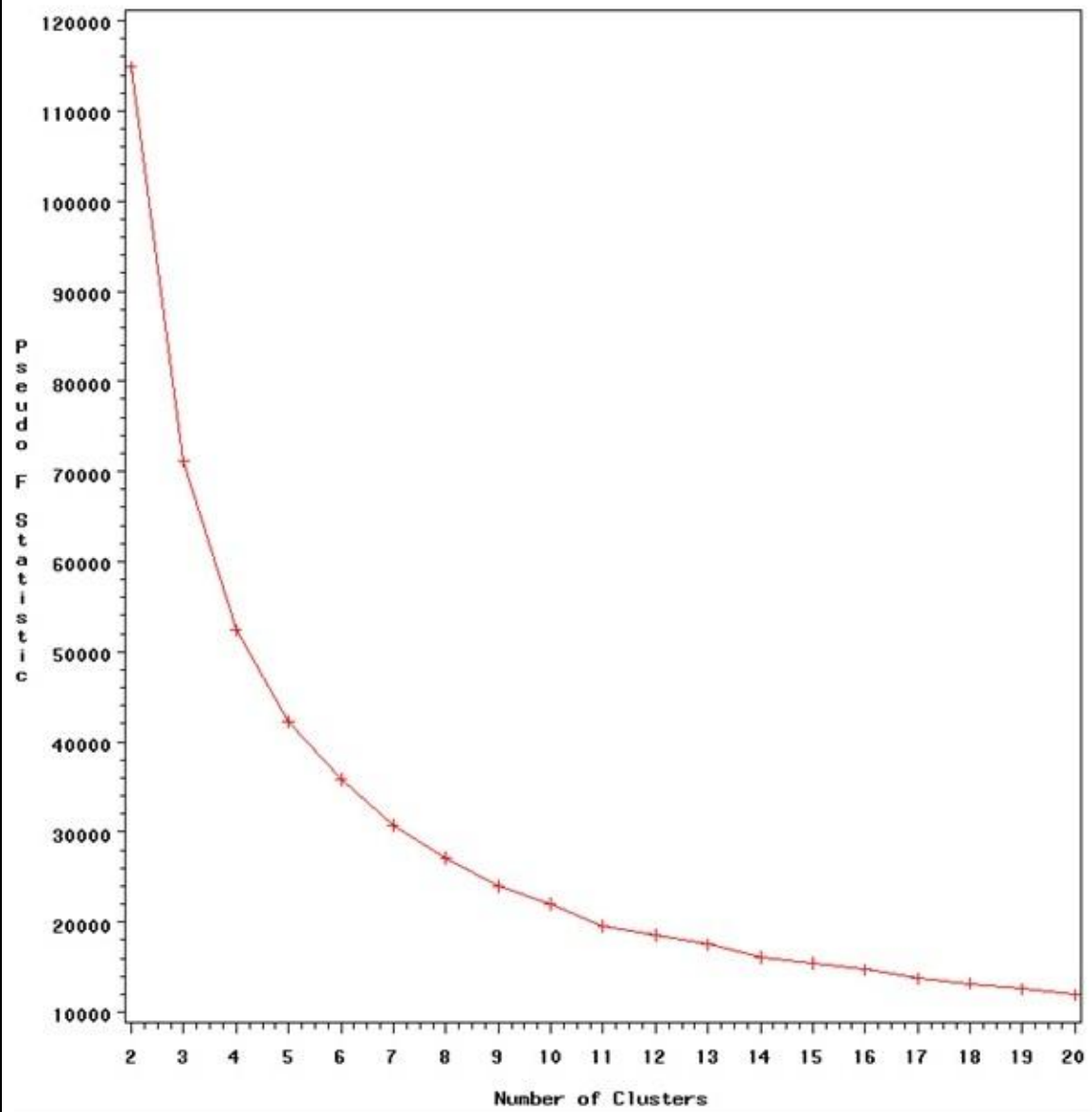
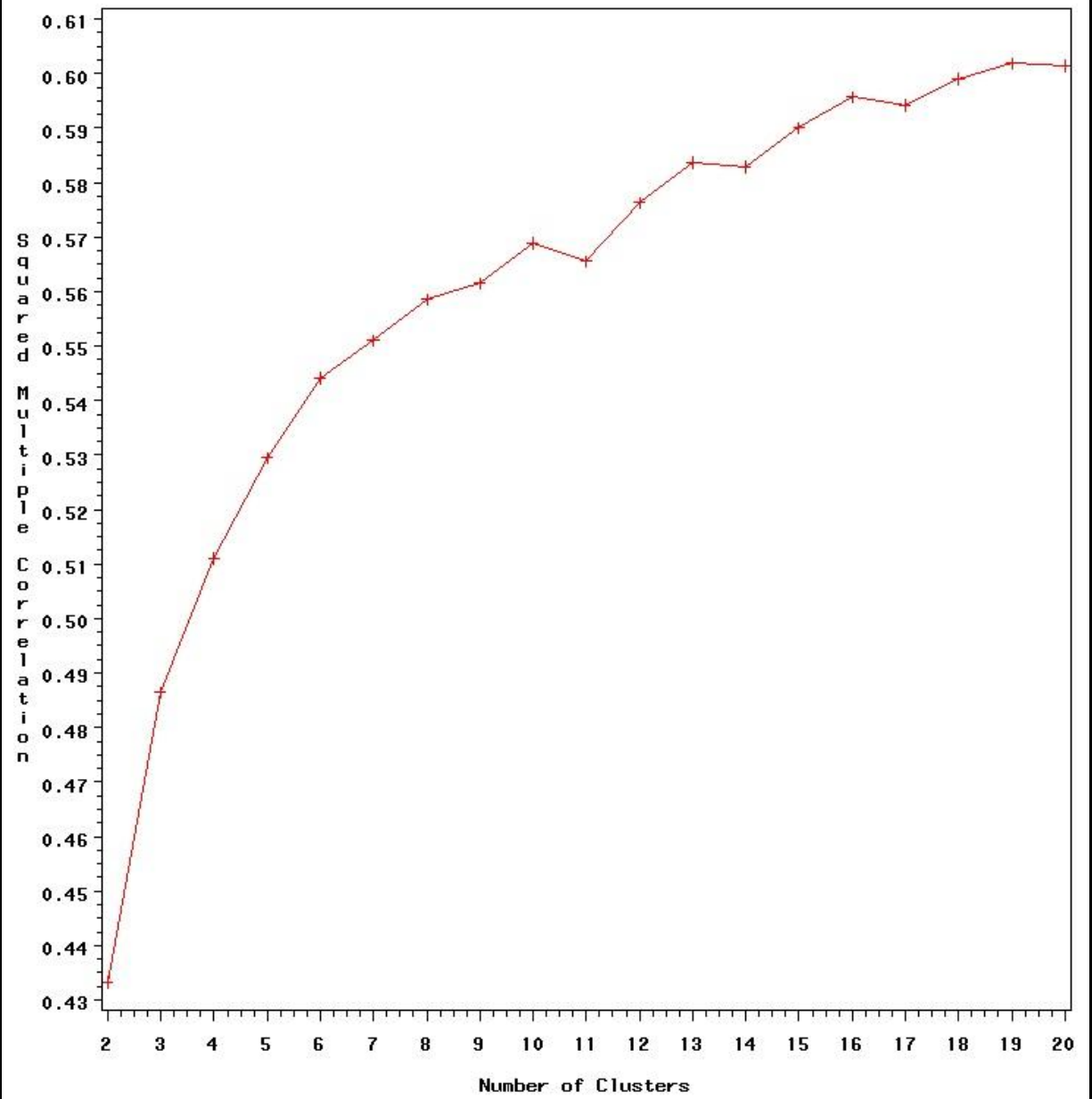


Figure 25. RSQ Plot for determining K in K-means Analyses





## Appendix 6 – Additional Outputs from Section 6.0

**Table 28.** Bivariate Logistic Regression Results – Predisposing

	Occupational Therapy		Physiotherapy	
	OR	OR	OR	95% CI
Age Group	0.960	(0.96-0.97)	0.942	(0.96-0.97)
Sex	0.947	(0.93-0.96)	0.981	(0.93-0.96)
Marital Status	1.073	(1.06-1.09)	1.218	(1.06-1.09)
French speaking	0.856	(0.81-0.90)	0.865	(0.81-0.90)

**Table 29. Bivariate Logistic Regression Model Results – Enabling**

	Occupational Therapy		Physiotherapy	
	OR	95% CI	OR	95% CI
Living Alone	1.047	(1.03-1.07)	0.930	(0.91-0.95)
Caregiver Not Satisfied	1.220	(1.16-1.29)	0.872	(0.82-0.93)
Caregiver Distress	1.350	(1.32-1.38)	1.014	(0.99-1.04)
Education*				
Unknown		*Reference*		*Reference*
HS or Less	1.005	(0.97-1.04)	0.899	(0.87-0.93)
University	0.957	(0.93-0.99)	0.919	(0.89-0.95)
Grad Degree	0.946	(0.91-0.98)	0.929	(0.90-0.97)
CCAC**				
1		*Reference*		*Reference*
2	1.011	(0.97-1.05)	0.894	(0.86-0.93)
3	1.221	(1.17-1.27)	1.696	(1.63-1.77)
4	2.182	(2.08-2.29)	2.136	(2.03-2.25)
5	1.332	(1.27-1.40)	1.922	(1.83-2.02)
6	2.481	(2.40-2.57)	2.667	(2.57-2.77)
7	1.929	(1.85-2.01)	1.449	(1.38-1.52)
8	1.498	(1.43-1.57)	1.855	(1.77-1.94)
9	0.555	(0.53-0.59)	0.889	(0.84-0.94)
10	1.673	(1.57-1.78)	1.558	(1.45-1.67)
11	1.060	(1.01-1.12)	1.123	(1.06-1.19)
12	1.781	(1.71-1.85)	1.616	(1.55-1.69)
13	1.263	(1.21-1.32)	0.917	(0.87-0.96)
14	3.237	(3.11-3.37)	3.066	(2.93-3.21)

\*OR are in relation to Education = Unknown

\*\*OR are in relation to CCAC = 1

Abbreviations: HS = High School; Grad = Graduate

**Table 30.** Bivariate Logistic Regression Model Results – Need: Scales

	Occupational Therapy		OR	95% CI
	OR	95% CI		
CPS	1.001	(0.99-1.01)	0.810	(0.80-0.82)
ADL Hierarchy	1.184	(1.18-1.19)	1.152	(1.14-1.16)
IADL Capacity	1.115	(1.11-1.12)	1.115	(1.11-1.12)
CHESS	1.327	(1.32-1.34)	1.272	(1.26-1.28)
MAPLe	1.132	(1.13-1.14)	0.989	(0.98-1.00)
Pain	1.164	(1.16-1.17)	1.356	(1.34-1.37)

**Table 31. Bivariate Logistic Regression Model Results – CAPs**

	<b>Occupational Therapy</b>		<b>Physiotherapy</b>	
	<b>OR</b>	<b>95% CI</b>	<b>OR</b>	<b>95% CI</b>
cPACTIV	1.238	(1.22-1.26)	1.342	(1.32-1.37)
cIADL	1.957	(1.93-1.99)	2.807	(2.76-2.86)
cADLimprove	0.712	(0.69-0.74)	0.481	(0.46-0.50)
cADLdecline	1.730	(1.70-1.76)	1.858	(1.82-1.89)
cENVIR	2.564	(2.47-2.66)	1.650	(1.59-1.72)
cRISK	1.370	(1.35-1.39)	1.039	(1.02-1.06)
cFALLShigh	1.385	(1.36-1.41)	1.707	(1.67-1.74)
cFALLsmed	1.819	(1.78-1.86)	1.777	(1.74-1.82)
cPAINhigh	1.167	(1.15-1.19)	1.472	(1.45-1.50)
cPAINmed	1.444	(1.41-1.48)	1.732	(1.69-1.78)

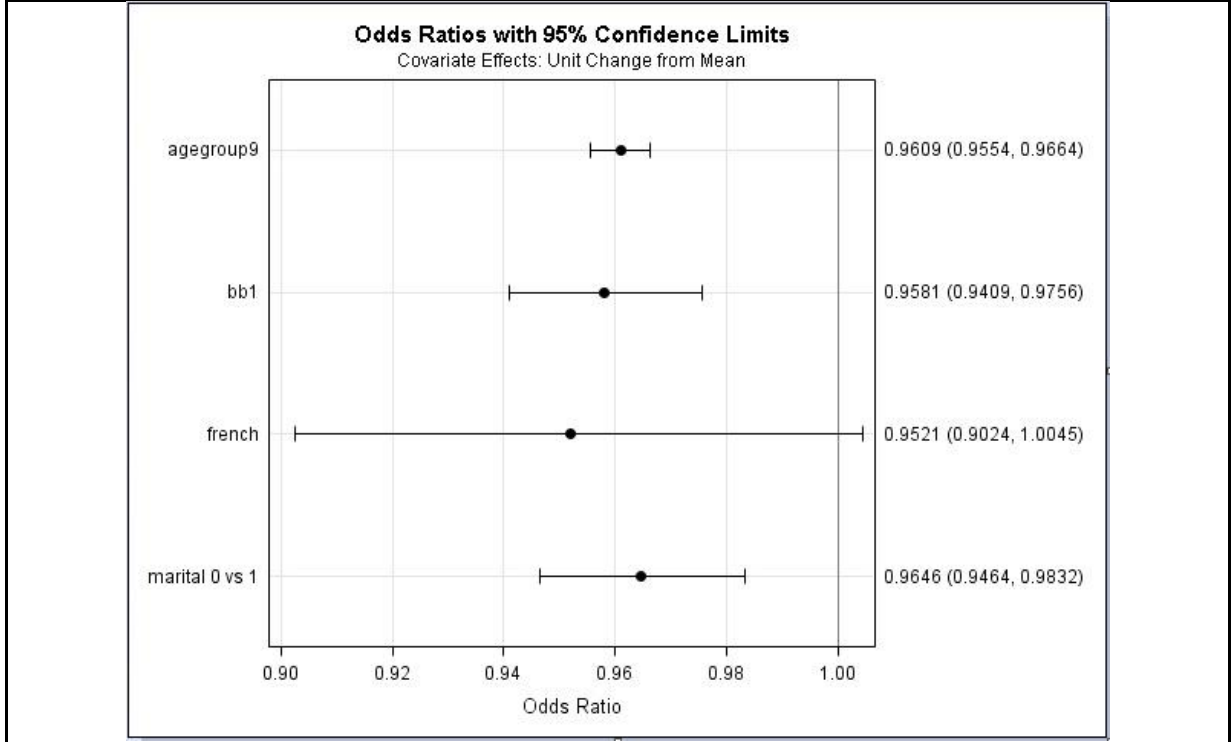
**Table 32.** Bivariate Logistic Regression Model Results – Need Factors: ADL Impairments and IADL Impairments

		Occupational Therapy		Physiotherapy	
		OR	95% CI	OR	95% CI
<b>IADL Impairment</b>	Meal Preparation	1.395	(1.37-1.43)	1.501	(1.47-1.54)
	Housework	1.511	(1.46-1.56)	2.026	(1.95-2.10)
	Managing Finances	1.259	(1.24-1.28)	1.009	(0.99-1.03)
	Managing Medications	1.160	(1.14-1.18)	0.921	(0.91-0.94)
	Phone Use	1.102	(1.08-1.12)	0.799	(0.78-0.82)
	Shopping	1.904	(1.85-1.96)	2.101	(2.03-2.17)
	Transport	1.559	(1.53-1.59)	1.668	(1.63-1.70)
<b>ADL Impairment</b>	Bed Mobility	1.942	(1.89-1.99)	1.885	(1.84-1.94)
	Transfer	1.911	(1.87-1.95)	2.001	(1.96-2.04)
	Locomotion in Home	1.724	(1.69-1.76)	1.873	(1.84-1.91)
	Locomotion Outside	1.761	(1.73-1.79)	2.134	(2.10-2.17)
	Dressing – Upper Body	1.506	(1.48-1.53)	1.504	(1.48-1.53)
	Dressing – Lower Body	1.561	(1.54-1.59)	1.699	(1.67-1.73)
	Eating	1.417	(1.39-1.44)	1.322	(1.30-1.35)
	Personal Hygiene	1.382	(1.36-1.41)	1.296	(1.27-1.32)
	Toilet Use	1.552	(1.52-1.58)	1.527	(1.50-1.56)
	Bathing	1.498	(1.47-1.53)	1.692	(1.66-1.73)

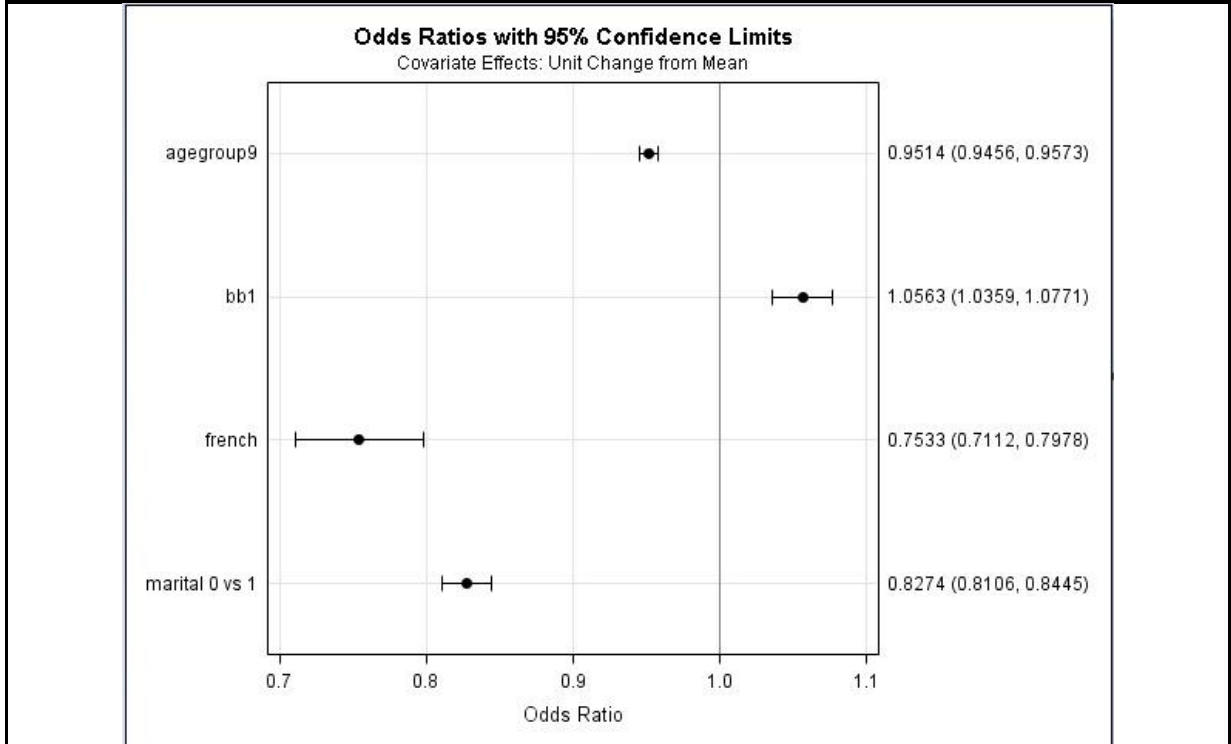
**Table 33. Bivariate Logistic Regression Results – Need Factors: Disease Diagnoses**

	Occupational Therapy		Physiotherapy	
	OR	95% CI	OR	95% CI
Cerebral vascular Disease	1.317	(1.29-1.35)	1.287	(1.26-1.32)
Congestive Heart Failure	1.092	(1.07-1.12)	1.560	(1.03-1.09)
Coronary Arterial Disease	1.078	(1.06-1.10)	1.123	(1.10-1.15)
Hypertension	1.088	(1.07-1.11)	1.152	(1.13-1.17)
Irregular Pulse	1.083	(1.06-1.11)	1.176	(1.14-1.21)
Peripheral Vascular Disease	1.058	(1.02-1.10)	1.083	(1.05-1.12)
Alzheimer's Disease (AD)	0.682	(0.66-0.70)	0.334	(0.32-0.35)
Dementia Not AD	0.872	(0.85-0.90)	0.529	(0.51-0.55)
Parkinson's	1.605	(1.54-1.67)	1.519	(1.46-1.59)
Arthritis	1.094	(1.07-1.11)	1.318	(1.30-1.34)
Hip Fracture	1.031	(0.99-1.74)	2.497	(2.40-2.59)
Other Fracture	1.282	(1.25-1.32)	1.973	(1.92-2.03)
Osteoporosis	1.073	(1.05-1.10)	1.198	(1.17-1.22)
Psychiatric Disorder	1.062	(1.03-1.09)	0.967	(0.94-1.00)
Cancer	0.881	(0.86-0.90)	0.790	(0.77-0.81)
Diabetes	1.106	(1.09-1.13)	1.081	(1.06-1.10)
COPD	1.129	(1.10-1.15)	1.125	(1.10-1.15)

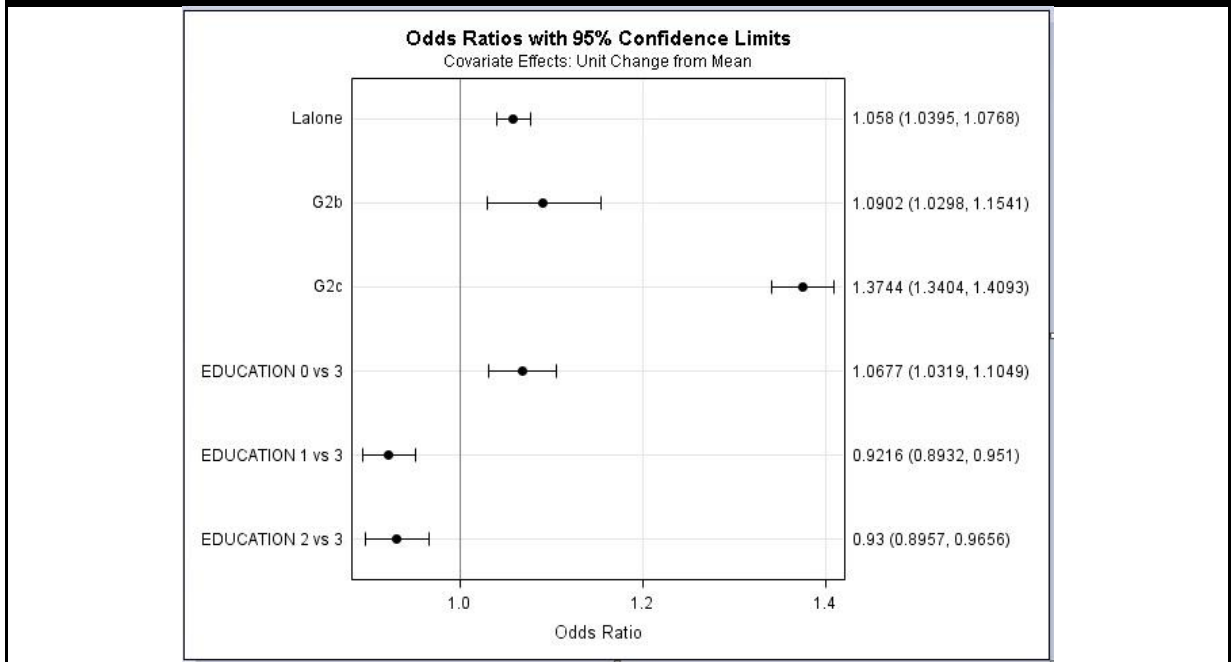
**Figure 26. MLM Odds Ratios for Predisposing – OT**



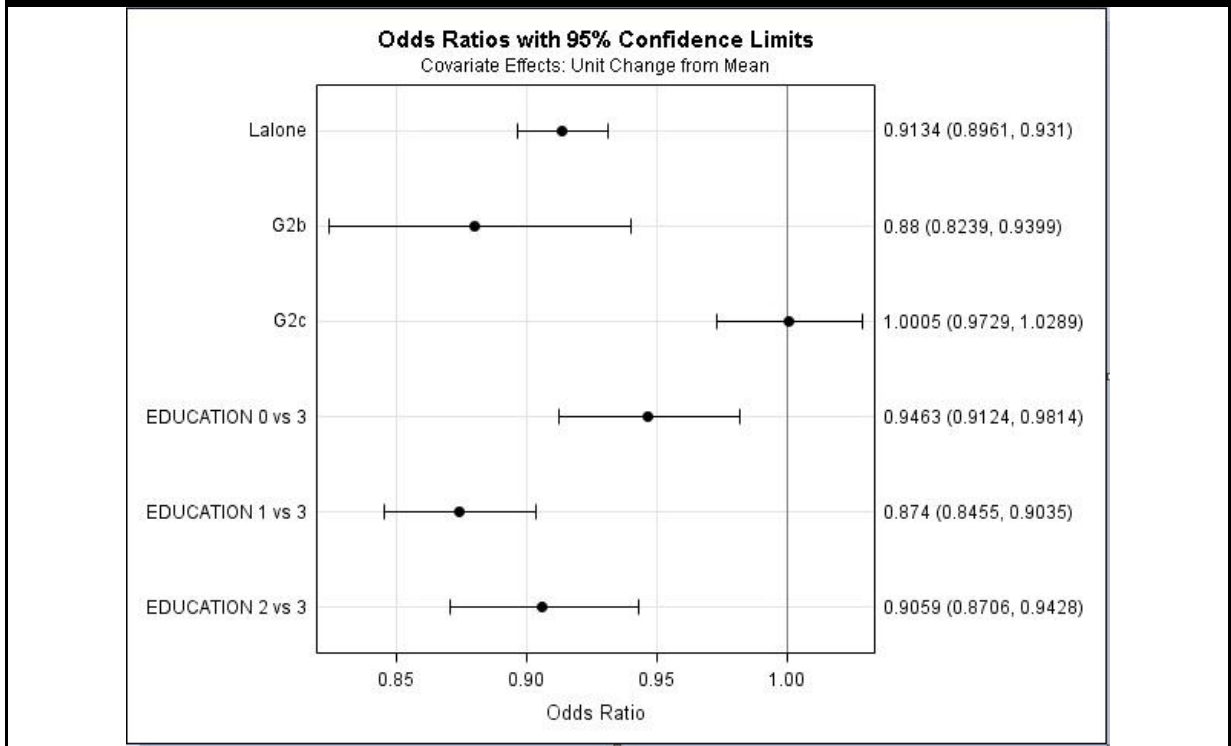
**Figure 27. MLM Odds Ratios for Predisposing – PT**



**Figure 28. MLM Odds Ratios for Enabling – OT**

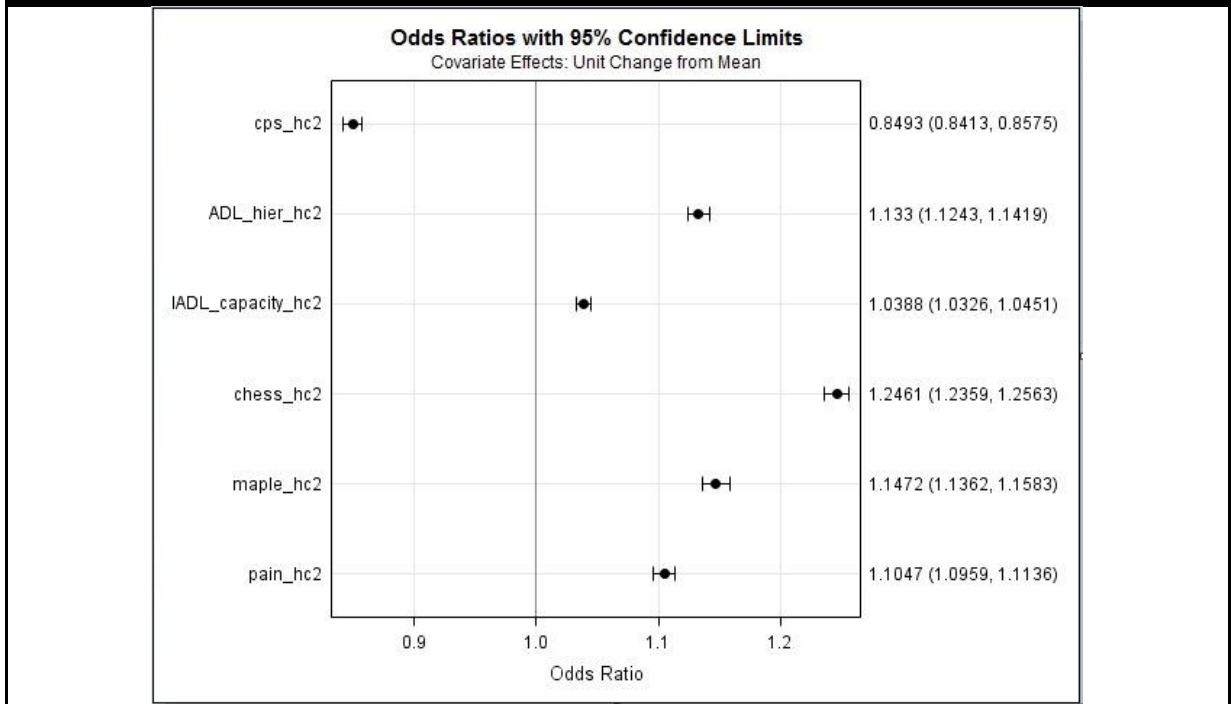


**Figure 29. MLM Odds Ratios for Enabling – PT**

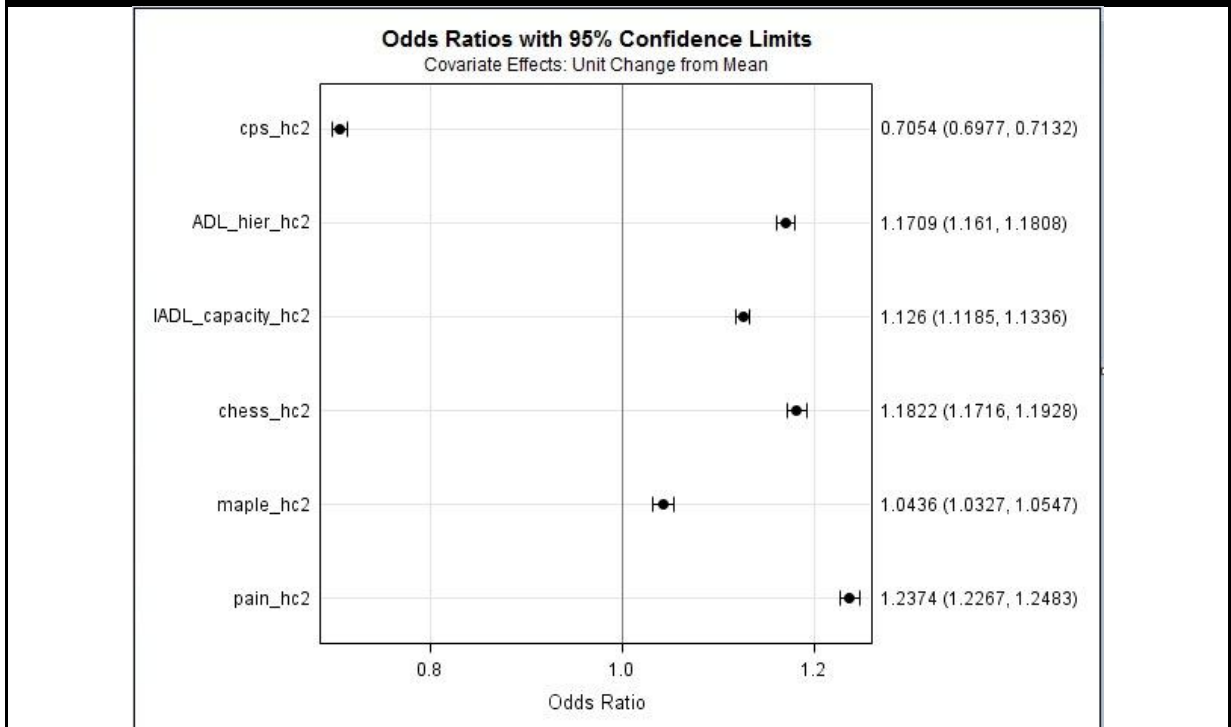




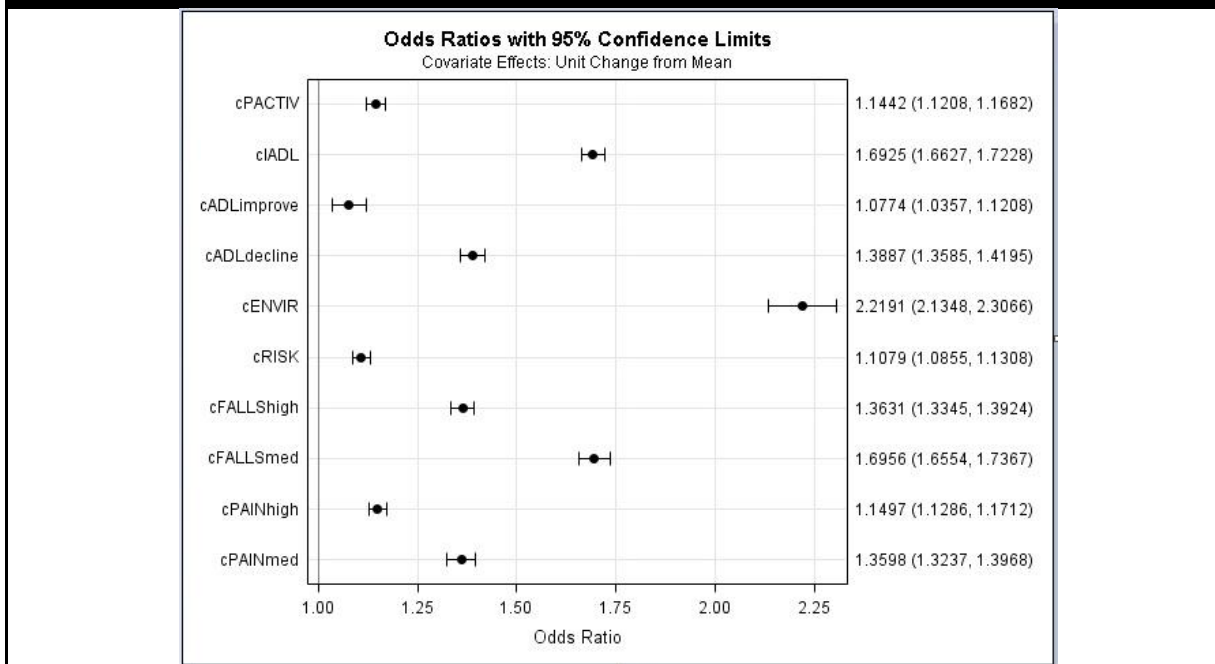
**Figure 30. MLM Odds Ratios for Need Factors – Scales - OT**



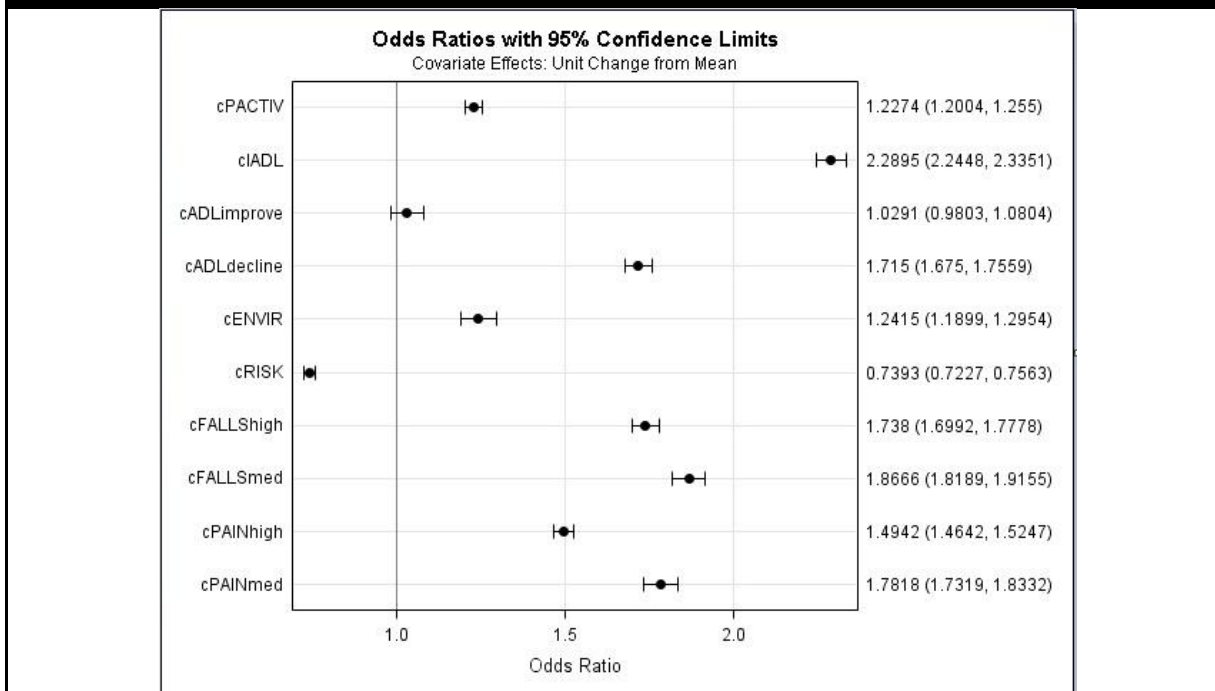
**Figure 31. MLM Odds Ratios for Need Factors – Scales - PT**



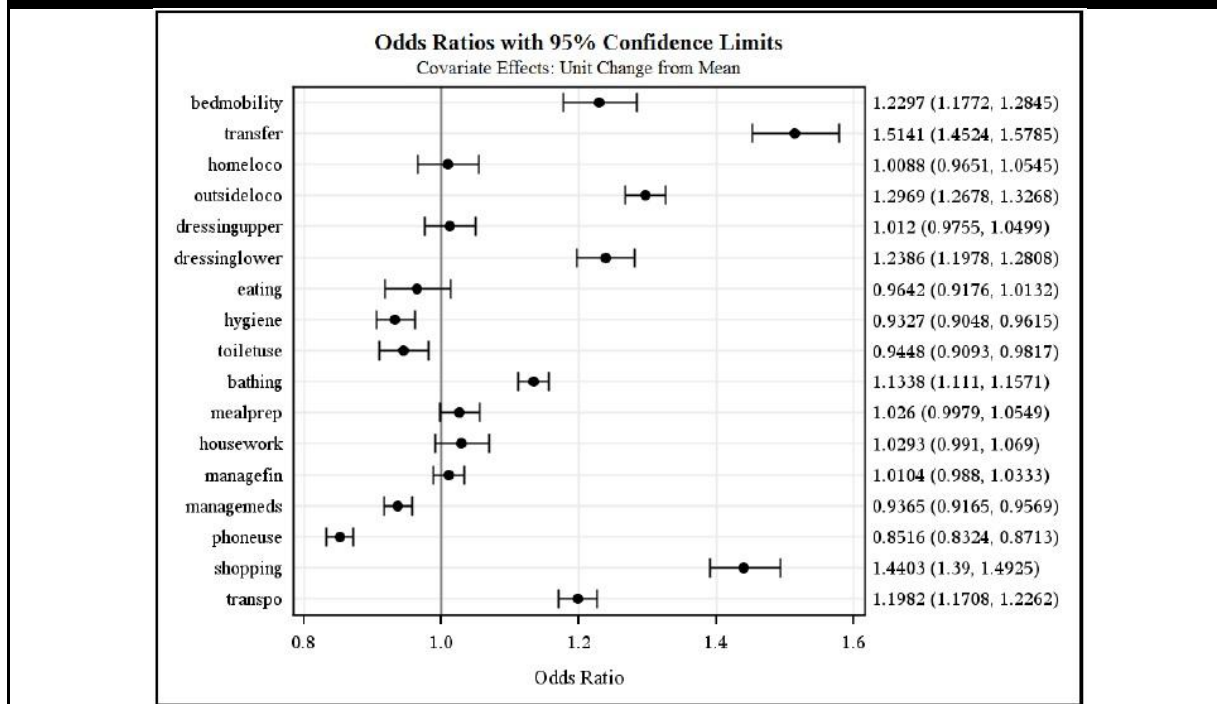
**Figure 32. MLM Odds Ratios for Need Factors – CAPs- OT**



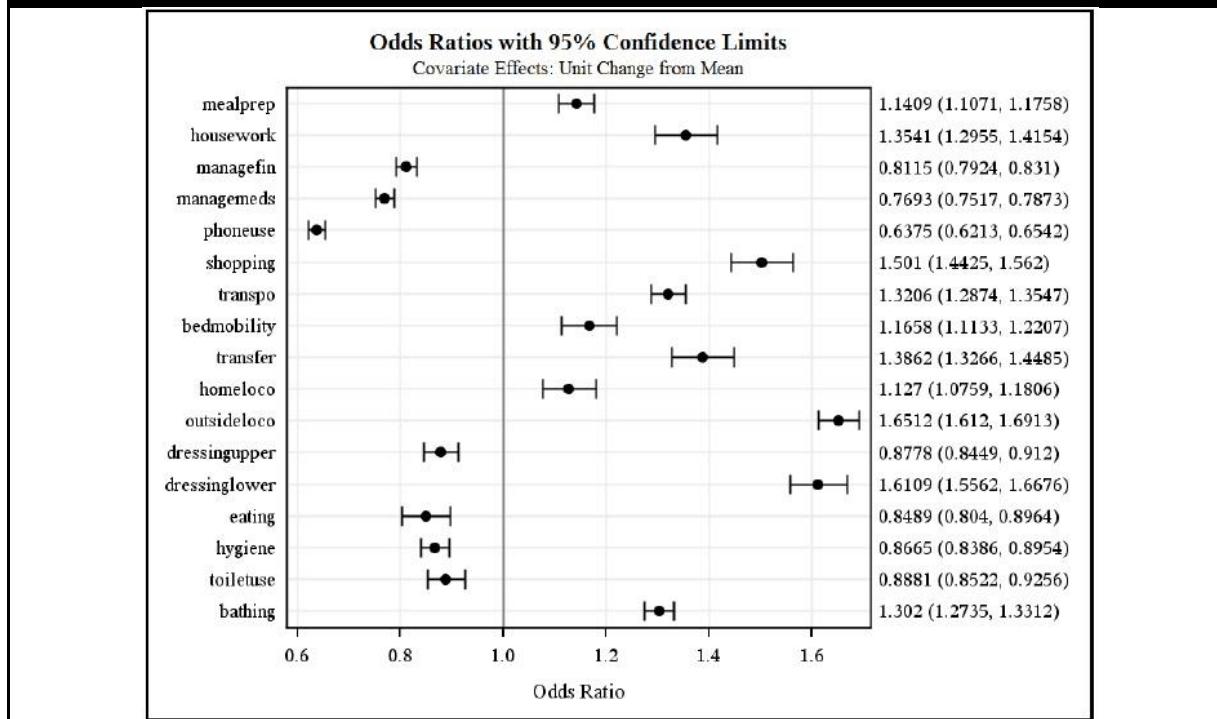
**Figure 33. MLM Odds Ratios for Need Factors – CAPs- PT**



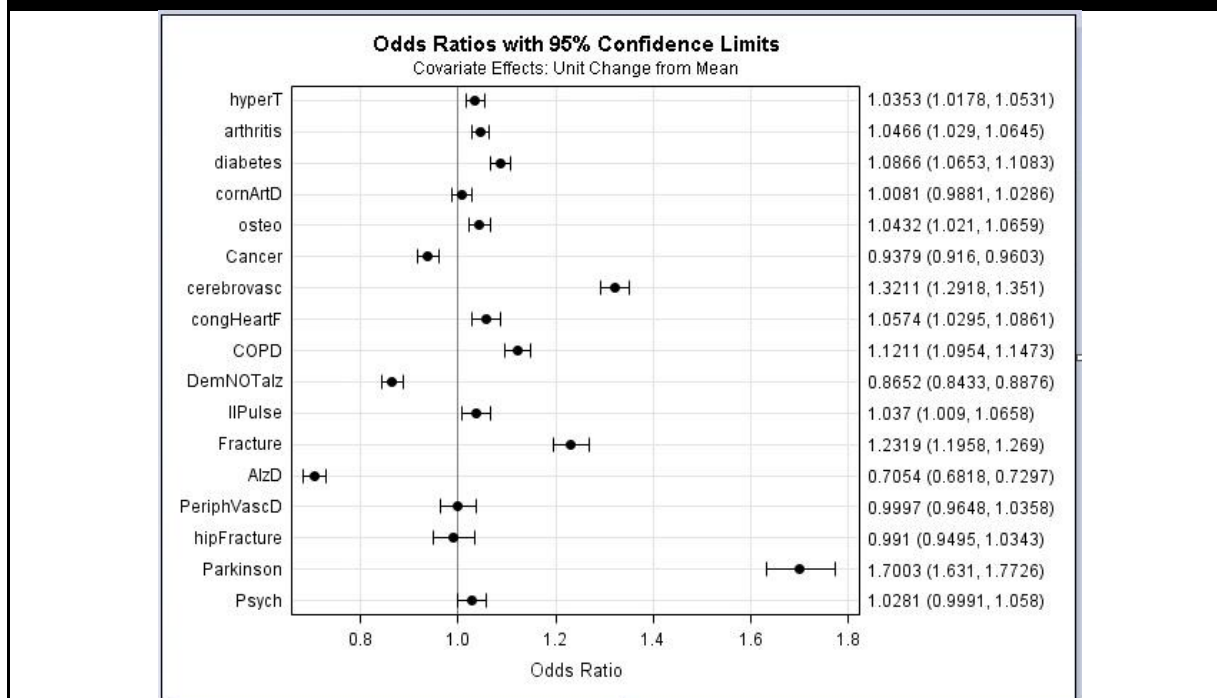
**Figure 34. MLM Odds Ratios for Need Factors – ADLs & IADLs - OT**



**Figure 35. MLM Odds Ratios for Need Factors – ADLs & IADLs - PT**



**Figure 36. MLM Odds Ratios for Need Factors – Disease Diagnoses – OT**



**Figure 37. MLM Odds Ratios for Need Factors – Disease Diagnoses – PT**

