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The Impact of Resource Availability on Patterns of Discharge to Inpatient Rehabilitation after Stroke in Ontario, Canada

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A thesis submitted in partial fulfillment of the requirements for the Doctor of Philosophy degree in Epidemiology and Biostatistics

THE IMPACT OF RESOURCE AVAILABILITY ON PATTERNS OF DISCHARGE TO INPATIENT REHABILITATION AFTER STROKE IN ONTARIO, CANADA

(Dissertation format: Integrated Article)

by

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Graduate Program in Epidemiology and Biostatistics

A thesis submitted in partial fulfillment
of the requirements for the degree of
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Abstract

Stroke is a leading cause of death and disability in Canada. As patients, their families, and their friends adjust to life after stroke, organized rehabilitation can play an important role in functional recovery and improving quality of life. Best-practice recommendations suggest that moderately-to-severely impaired patients receive care in an inpatient rehabilitation unit and more mildly impaired patients in out-of-hospital settings (outpatient clinics or in-home). However, data from Ontario (Canada's most populous province) suggest that post-stroke rehabilitation resources in both settings may be lacking. This has led to concern that some patients may be receiving rehabilitation that is not appropriate for their needs, while others receive none at all. The objective of this thesis was to formally test the hypotheses that access to rehabilitation varies across the province and that this variation is due, in part, to limited availability of rehabilitation resources. An integrated article approach was adopted consisting of two literature reviews and two original research papers.

Literature reviews were performed to identify patient-level variables that can be used to 1) predict functional outcomes after inpatient rehabilitation and 2) infer suitability for early supported discharge to community-based rehabilitation. Findings from the first review were used to inform analyses testing variation in the proportion of patients discharged to inpatient rehabilitation across regions of Ontario, while adjusting for patient-level characteristics. Hierarchical logistic regression confirmed variability in referral patterns across the province, but mixed results in the association between resources and the adjusted probability of discharge to rehabilitation. Results from the second review were used to inform an ecological study of regional variation in the proportion of mild stroke patients unnecessarily admitted to inpatient rehabilitation after stroke across Ontario. This study also confirmed suspicions that variability exists across the province and suggested an association with the availability of in-home rehabilitation services. In combination, these articles offer Ontario's policy makers confirmation of regional inequity in access to post-stroke rehabilitation and evidence to justify further exploration into the possibility that regional investment in rehabilitation may have a positive effect. The methods proposed here may also be useful in informing future health system evaluations.

Keywords

Stroke, cerebrovascular accident, rehabilitation, health services, health policy, hierarchical logistic regression, multi-level model, ecological study.

Co-Authorship Statement

Chapter 2. Andrew McClure, Shelialah Pereira, and Marina Richardson offered support with study design and assisted with article review. Andrew and Shelialah acted as second reviewers during article screening. Marina acted as second scorer of study quality. All three reviewed the final manuscript.

Chapter 4. Jiming Fang and Eriola Aslani are analysts at the Institute for Clinical Evaluative Sciences in Toronto, Ontario. Jiming and Eriola informed development of the multi-level model, provided a template for the SAS code used in the analyses, and executed all analyses.

Dedication

I dedicate this dissertation to my family, who may never know how much they mean to me.

To my mother and father, Trudy and John, who taught me to think critically, be humble, and strive to make positive change. Thank you for always being there for me.

To my sister Samantha, whose success has been an inspiration to me and who continues to amaze me in the way she lives her life.

To my children Olive, Hugh, Thomas and Eleanor, whose enthusiasm and energy inspire me every day and who help me to remember what life is all about.

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Abbreviations and Acronyms

ALC – Alternate Level of Care
BI – Barthel Index
CBPR – Canadian Best-Practice Recommendations for Stroke
CCAC – Community Care Access Centres
CIHI – Canadian Institute for Health Information
CIHR – Canadian Institute for Health Research
CNS – Canadian Neurological Scale
DAD – Discharge Abstract Database
ED – Emergency Department
ESD – Early Supported Discharge
FIM® - Functional Independence Measure
HSF – Heart and Stroke Foundation
HQO – Health Quality Ontario
ICD – International Classification of Diseases
ICES – Institute for Clinical Evaluative Sciences
LHIN – Local Health Integration Network
LTC – Long-Term Care
MMSE – Mini Mental State Exam
MoHLTC – Ministry of Health and Long-Term Care
mRS – modified Rankin Scale
NIHSS – National Institute of Health Stroke Scale
NRS – National Rehabilitation Reporting System
OAI – Onset-Admission Interval
OSA – Ontario Stroke Audit
OSN – Ontario Stroke Network
OSS – Ontario Stroke Strategy
OT – Occupational Therapy
PT – Physical Therapy
RPG – Rehabilitation Patient Groups
SLP – Speech Language Pathology
SW – Social Work
TIA – Transient Ischemic Attack

Chapter 1 – Introduction and Overview

1.1 Background

This dissertation was motivated by concern that some patients who experience a stroke in Ontario, Canada are unable to access the rehabilitation they need, while others are receiving rehabilitation that is inappropriate for their needs. The objective was not only to validate these concerns, but also to begin to explore ways in which the design of Ontario's stroke rehabilitation system may be contributing to them and propose tools that can be used for system evaluation in the future. This initial chapter will serve as a brief introduction to stroke and some of the challenges faced by Ontario's stroke rehabilitation system. It will also introduce some of the initiatives under way in Ontario to address these challenges.

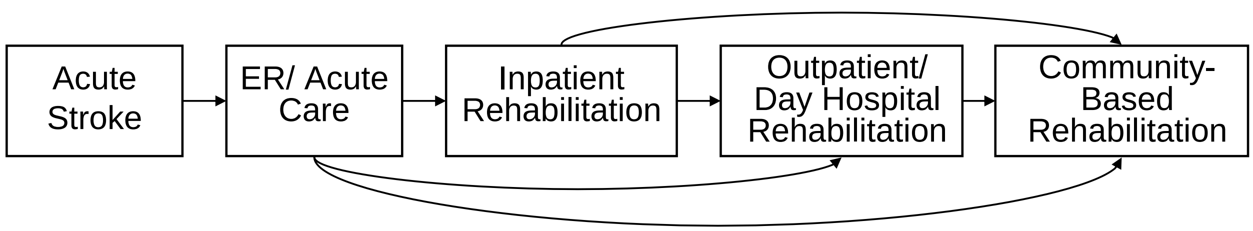
Stroke is a leading cause of death and disability in Canada [1, 2] and its management presents a major challenge to Canada's healthcare system. The American Heart Association defines a stroke as an event where cell death in the central nervous system (brain, spinal cord, or retina) results from a non-traumatic loss of oxygen.[3] Strokes are divided into two broad etiologic categories: ischemic and hemorrhagic. In an ischemic stroke the loss of oxygen is caused by a blockage (thrombosis) of one of the arteries supplying blood to the central nervous system. In hemorrhagic strokes, oxygen deprivation results from a focal collection of blood in the brain tissue, or ventricles, not resulting from acute trauma.[3] However, within these categories the patient's experience of a stroke can vary dramatically. Depending on the size and location of the affected region, impairments experienced by the patient can range from severe functional deficits or death, to none at all. Stroke-care systems, therefore, must be equally diverse and able to respond to a wide range of patient needs.

The Heart and Stroke Foundation (HSF) of Canada estimates as many as 50,000 incident strokes occur each year in Canada and that more than 300,000 individuals are living with the effects of stroke at any point in time.[2] Ontario is Canada's most populous province and its residents account for approximately 40% of these new strokes.[4] Crude estimates suggest that approximately 15% of patients who experience a stroke will die in hospital and 10% will recover completely; the remaining 75% are left with functional impairments that may require some ongoing rehabilitation.[2] While there is a wealth of evidence demonstrating the benefits of various forms of rehabilitation after stroke,[5] decisions regarding the optimal setting for care are not always clear. In Ontario, three forms of post-stroke rehabilitation are available to patients: inpatient rehabilitation, outpatient rehabilitation, and community-based rehabilitation (usually provided in-home). Planning and coordinating these services across Ontario's diverse geography presents significant challenges for both stroke rehabilitation providers and the decision makers who allocate funding.[6]

Regional context is an important consideration in system planning, and healthcare systems around the world have adopted markedly different approaches to managing stroke rehabilitation. In the United States, inpatient rehabilitation resources are largely reserved for patients with clearly demonstrable potential for recovery very early after the stroke event and patients are discharged from care as soon as possible.[7] Conversely in countries like Australia and Israel, the majority of patients are admitted to inpatient rehabilitation as soon as possible after stroke and triage decisions for ongoing care are coordinated there.[8, 9] In the United Kingdom, heavy investment has been made in early supported discharge and community-based rehabilitation, so patients are often discharged directly to these services without being admitted to inpatient rehabilitation.[10] Each of these strategies has strengths and limitations. The challenge faced by Ontario is to develop a stroke rehabilitation strategy that fits within Canada's universal healthcare system and addresses the geographic diversity of the province.

Nearly all patients who experience a stroke in Ontario are directed to an emergency department, which becomes their first point of contact with the healthcare system.[11] Patients with neurological deficits, or those deemed to be at risk of a recurrent event, are admitted to an acute bed where they receive a thorough diagnostic work-up and medical management. Once these patients are deemed medically stable, decisions about discharge destination take place, which often include input from clinical personnel, the patient, family and friends. Patients referred for rehabilitation enter the system as outlined in Figure 1.1. Although discharges directly to outpatient and community-based rehabilitation are possible, the majority of patients who access these programs are first admitted to acute care and inpatient rehabilitation.[11]

Figure 1.1 – Schematic diagram of typical patient progress through Ontario's stroke rehabilitation system



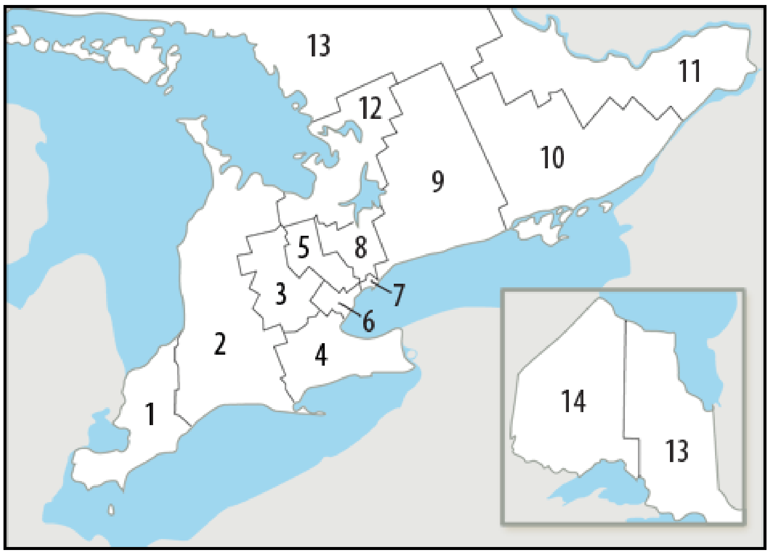
The Canadian Best-Practice Recommendations for Stroke (CBPR) suggest that all patients who experience a stroke receive a formal assessment to determine their rehabilitation needs, and that this be performed by staff with expertise in stroke.[12] However, rather than list specific criteria by which this decision should be made, the recommendations acknowledge the need for flexibility in needs assessment to account for regional context. In section 5.1, the CBPR recommend that admission criteria be established for each rehabilitation setting and that these criteria be communicated to all referring centres and services.[12] As a consequence, decisions about discharge to inpatient rehabilitation across the province may sometime vary from region to region appropriately.

In practice, discharge decisions are rarely based on clinical criteria alone.[8, 13, 14] Factors including the proximity of inpatient rehabilitation facilities, patient choice, resource availability (the number of inpatient beds and/or outpatient or community-based rehabilitation programs etc.), and the knowledge level and/or engagement of care providers may also contribute to the final decision. These factors can vary dramatically from region to region in Ontario and may represent non-clinical factors that impact the ability of patients to access the rehabilitation they need. While strategies for rehabilitation provision vary between jurisdictions, inpatient rehabilitation has traditionally received the bulk of funding in all regions.[15] Hospital-based outpatient programs and in-home rehabilitation services (generally coordinated by Community Care Access Centers, CCACs, in Ontario) often receive the least attention and are the first to experience budget cuts.[15]

Ontario is a large province spanning more than one million square kilometers. Residents of Ontario live in a variety of settings ranging from large metropolitan cities to remote rural outposts accessible only by air. This presents tremendous challenges when trying to establish provincial health policies. In 2000, Ontario's Ministry of Health and Long-Term Care (MoHLTC), in collaboration with the HSF, supported the development of the Ontario Stroke System (OSS) to help promote reorganization of stroke services in the province according to best-evidence.[6] The OSS was designed to support dissemination of stroke best-practice information and to perform system evaluation across the province. Eleven stroke regions were established and within each were developed designated and regional stroke centers. Each region was also provided with a program director to support care coordination and training. In the stroke care community, this coordination served to help providers and planners think more regionally about provision of all stroke services, including rehabilitation.[6]

In 2004, Ontario's government also began to address regional challenges in healthcare provision by initiating a process to divide the province into 14 Local Health Integration Networks (LHINs, Figure 1.2). On April 1st 2007, these LHINs officially took charge of planning, integrating and distributing provincial funding for most local healthcare services. The LHIN boundaries were established to capture smaller, more homogeneous regions of the province, which offer an excellent opportunity for system-level comparison between geographically distinct regions. Prior to 2007, LHIN boundaries can be used to retrospectively evaluate differences in healthcare provision between geographically distinct regions dealing with distinct challenges (eg. population demographics and density). Since 2007, LHIN-led initiatives and coordination strategies have resulted in the evolution of 14 slightly different stroke systems, which provides an additional opportunity for health policy evaluation.

Figure 1.12 - Map of Ontario's Local Health Integration Network (LHIN) Boundaries



(Source: Ontario LHINs[16])

Ontario-based research suggests that the proportion of stroke survivors discharged from acute care to inpatient rehabilitation should be approximately 40%.[17, 18] Yet, crude analyses suggest that few regions are approaching this target, and variation in access to post-stroke rehabilitation services persists across the province. In 2008, one year after the LHINs were formed, the OSS reported that 23% of stroke patients discharged alive from an acute facility were admitted to inpatient rehabilitation and that the proportions ranged from 14-39% across LHINs.[4] In 2011, the provincial average improved to 32% and the range narrowed to 24-39% - a move in the right direction. However, the crude analyses used to generate these estimates mean that researchers and policy makers continue to lack information about whether the remaining variation is appropriate (i.e. reflects differences in patient characteristics) or inappropriate (i.e. reflects inequitable access to inpatient rehabilitation between regions).

The 2008 patterns of discharge to inpatient rehabilitation in Ontario suggested another troubling trend beyond limited access to rehabilitation services. The authors of a stroke system evaluation in that year noted that, on average, milder stroke patients were increasingly being admitted to inpatient rehabilitation across the province, and that this may be further limiting access to inpatient rehabilitation for patients who have experienced more severe strokes.[4] One possible explanation for this trend is that decreasing availability of outpatient and/or community-based rehabilitation programs leads physicians in Ontario to refer patients to inpatient rehabilitation instead, unnecessarily. If clinicians are concerned about their patients' ability to receive care after discharge, they may be inclined to admit them to inpatient rehabilitation for a short period to ensure they receive some therapy. If so, these unnecessary admissions to inpatient rehabilitation are costly both in dollars spent[19] and in lost opportunity to provide inpatient rehabilitation to more appropriate candidates.[20]

Resource allocation is a modifiable factor that may play a significant role in our ability to provide rehabilitation to patients in need. Understanding the relationship between rehabilitation resources and patterns of referral to inpatient rehabilitation after stroke is an important part of developing an effective and efficient stroke rehabilitation system in Ontario. At the heart of this dissertation is the question of how rehabilitation resource availability contributes to some people being unable to get the rehabilitation they need after stroke, while others may be getting rehabilitation that is inappropriate for their needs.

1.2 Project Overview

The objective of this dissertation was to examine the impact of the availability of post-stroke rehabilitation resources on patterns of discharge to inpatient rehabilitation across Ontario. The study tested two hypotheses, each of which consisted of a primary hypothesis and, if confirmed, a secondary hypothesis.

Hypotheses 1 and 1a

1. In Ontario, the probability of being discharged to inpatient rehabilitation after stroke varies between LHIN regions, after adjusting for patient-level characteristics.

    a. If confirmed, it was further hypothesized that a significant proportion of this variation could be explained by the relative availability of inpatient rehabilitation.

Hypotheses 2 and 2a

2. In Ontario, unnecessary admissions of mild stroke patients to inpatient rehabilitation vary significantly between LHIN regions.

    a. If confirmed, it was further hypothesized that a significant proportion of this variation could be explained by the relative availability of in-home rehabilitation.

These two separate, but related, hypotheses required two lines of inquiry. This dissertation applied an integrated-article approach resulting in four research articles. The first two, Chapters 2 and 3, are literature reviews designed to improve our understanding of patient criteria that can be used to assess suitability for rehabilitation after stroke (inpatient and in-home respectively). The following two chapters (4 & 5) build on these findings to explore the relationship between rehabilitation resource availability and patterns of discharge to inpatient rehabilitation in Ontario. After reviewing this dissertation, it is hoped that the reader will be left with a clear understanding of some of the policy-level challenges faced by Ontario's stroke rehabilitation system, but also a sense that the work being completed today is paving the way for a more patient-centered and efficient stroke rehabilitation system in the future.

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Chapter 2 - A Systematic Review of Studies Reporting Multivariable Models to Predict Functional Outcomes After Post-Stroke Inpatient Rehabilitation

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2.1 Introduction

Estimates suggest that as many as 300,000 Canadians are living with the effects of stroke at any one time[1] and caring for these patients costs the Canadian healthcare system up to $3.6 billion annually.[2] There is abundant evidence suggesting that, for suitable patients, inpatient rehabilitation can help improve function and decrease disability post stroke[3]; however, debate continues over how to identify suitable candidates.

Admission to a rehabilitation unit after stroke can be expensive. In 2008, the Canadian Institute for Health Information estimated that an average stay in inpatient rehabilitation cost $18,796[4], and a recently published economic evaluation reported the *per diem* cost of inpatient rehabilitation in Canada at $592.[5] In a world of tight healthcare budgets, clinicians considering a referral to inpatient rehabilitation must make important judgments about which patients are likely to benefit. While no one wants to deny appropriate patients access to rehabilitation that may benefit them, admission of patients who are not likely to improve can be seen as a waste of resources.

In a 2011 review, an extensive literature base assessing patient characteristics that could be used to predict functional outcomes and discharge destination after acute care was identified.[6] In that review, age, functional level post stroke, urinary incontinence and post-stroke cognition were consistently found to predict functional outcomes after acute care. The authors reported, however, that the timing of outcome measurement varied dramatically between studies. In separate analyses, the same review also found that the factors most frequently used for rehabilitation selection were age, pre-stroke functional level, and functional level after stroke; while age, severity of impairment, presence of hemiparesis, cognition, and functional level were most frequently associated with acute hospital discharge disposition in general.[6] While this review provides an excellent source of information on acute variables frequently used for inpatient rehabilitation selection, questions remain about which variables best predict patients' potential to benefit from this rehabilitation.

Given the importance of decisions about rehabilitation suitability, a large number of studies have developed statistical models to identify variables available at the time of acute discharge that are useful in predicting functional outcomes after inpatient rehabilitation. Many of these studies have utilized multivariable models, which are powerful tools for distinguishing key predictive variables from confounders.[7] The purpose of this systematic review was to identify published, peer-reviewed studies that presented one of these multivariable models and to summarize the findings on the candidate variables explored.

2.2 Methods

A systematic review of four electronic databases (Medline - Ovid, EMBASE - Ovid, PsycINFO – ProQuest and CINAHL – Ebsco Host) was conducted. Search strategies were designed to identify peer-reviewed, published manuscripts that presented a multivariable model predicting outcomes at discharge from inpatient rehabilitation using only variables available at acute discharge. In this review, only models predicting Barthel Index (BI) and Functional Independence Measure (FIM®) scores as the dependent variable were included. The BI and FIM® were selected as the outcome of interest because of their common use as global measures of functional independence after stroke and the frequency with which they are used as criteria for patient selection for inpatient rehabilitation after stroke.[6, 8]

The BI is a widely used measure of functional disability that measures a patient's ability to perform 10 activities of daily living, each assessed as either dependent or independent.[9] There are 8 items pertaining to personal activities and 2 to mobility. Depending on the iteration of the BI used, final scores range from zero to 20 (in increments of 1) or 100 (in increments of 5) where, in either case, a higher score indicates greater functional ability. The BI has been extensively tested for reliability and validity and has demonstrated good to excellent reliability based on test-retest, inter-observer, and internal consistency measures. It has also been consistently demonstrated to be valid based on measures of predictive, concurrent, construct and convergent validity in patients with stroke.[10] The BI is commonly used as the criterion standard for assessment of validity of other measures in stroke care. [10]

The FIM® instrument was modeled after the BI, but designed to be more sensitive and comprehensive. Rather than assess disability, the FIM® measures burden of care and is composed of 18 items assessing 6 areas of function.[11] Thirteen items evaluate the burden of care associated with motor function and 5 assess cognitive function. Each item is scored on a 7-point Likert scale where 1 denotes complete dependence and 7 complete independence. The items can be summed into a total score ranging from 18-126 where higher scores denote greater functional independence. The FIM® has also been extensively studied and has demonstrated excellent test-retest and inter-observer reliability as well as strong predictive, concurrent, and content validity in patients with stroke.[10]

The electronic databases were searched for articles published prior to January 1, 2013. Search strategies were developed in conjunction with a research librarian at Western University, London Ontario. Complete search strategies are presented in Appendix A, but were designed to include search terms corresponding to 4 themes: acute medical data AND stroke AND rehabilitation AND prediction. Only studies published in English were considered for inclusion.

Titles and abstracts were each screened by two reviewers (MM and AM or SP). Article inclusion criteria were set as follows:

- manuscript presents results from a multivariable model
- all patients included in the model had a primary diagnosis of stroke
- all patients received post-acute inpatient rehabilitation
- only patient variables available at acute discharge were explored as candidate predictors
- the dependent variable in the model was either BI or FIM® score at discharge from inpatient rehabilitation

During title and abstract screening, disagreements between reviewers were resolved through discussion. When disagreement about inclusion of an article could not be resolved, the article was pulled for full review. Each of the retrieved articles was then read in its entirety by two independent reviewers (MM and SP) and again screened for inclusion. Reference searches were also performed to identify articles missed by the initial search.

Each article that met all inclusion criteria was scored for methodological quality using the Quality in Prognosis Studies tool (QUIPS)[12] by two independent reviewers (MM and MR). Discrepancies were settled through discussion. The QUIPS tool consists of prompting questions related to 6 areas where bias is likely to be introduced in prognostic studies: participation, attrition, prognostic factor measurement, confounding measurement and account, outcome measurement, and analysis and reporting. A score of low, moderate, or high potential for bias was assigned to each study in each domain based on the prompting questions from QUIPS [12] and evaluation criteria developed specifically for this review (Appendix B) as recommended by the QUIPS developers [12]. Studies that were deemed to have a high potential for bias in any domain were excluded from analysis.

Final articles deemed suitable for inclusion were read by two reviewers (MM and SP or AM) and data extraction forms were completed. The two reviewers met regularly to compare charts and ensure data accuracy. Information about each individual model abstracted from all eligible studies included sample size, type of statistical analysis performed, predictive accuracy, outcome, candidate predictors explored, significant predictors identified (at $p<0.05$), and the direction of effect. Direction of effect was recorded as the relationship between presence of the variable (or higher scores) and higher BI or FIM® scores (or greater gain/efficiency). As an example, if a positive association between a variable and lower BI scores was reported in the study, this was recorded as a negative association between that variable and higher BI scores for purposes of this review. In order to simplify presentation, candidate variables were categorized into 4 groups: stroke characteristics and consequences, medical history/comorbidities/risk factors/biomarkers, demographic/ social data, and processes of care. Within each group, results for each candidate predictor were pooled to assess the number of times they were explored, the proportion of times they functioned as a significant predictor (overall and separately for each outcome), and the direction of effect. Candidate predictors are presented exactly as they were defined in the studies identified and only pooled when their definitions overlapped exactly.

2.3 Results

A flow chart of output from the systematic review is presented in Figure 2.1. After removal of duplicates, 3260 studies remained from the original search and were screened. Due to the breadth of the search strategy, a large number of articles were excluded based on title alone (articles modeling cardiac function and 'stroke volume' primarily). Of the 397 studies retrieved and read in their entirety, 370 were excluded based on the content of the full manuscript (primary reasons for exclusion are presented in Table 2.1).

Figure 2.31- Flow chart of results from systematic review of studies reporting multivariable models predicting functional outcomes after post-stroke rehabilitation

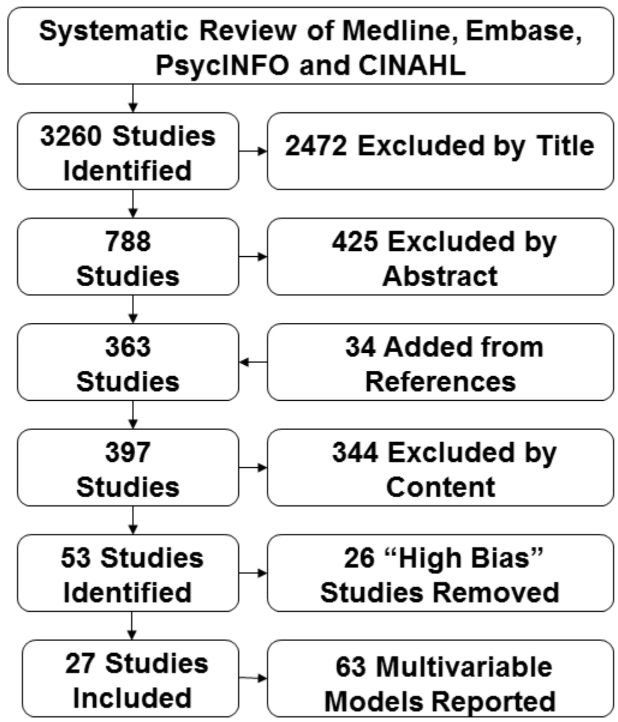

Table 2.1 – Primary reasons for exclusion of studies predicting functional outcomes after post-stroke rehabilitation reviewed in their entirety

Reason for Exclusion	#	Reason for Exclusion	#
No regression model presented	**68**	Outcome not FIM® or BI	**68**
Rehabilitation variables included in model	**63**	Not all patients received inpatient rehabilitation	**38**
No multivariable model presented	**36**	Acute rehabilitation only	**35**
"High Bias" in at least 1 QUIPS domain	**26**	Not all stroke (no sub-group analysis)	**11**
Review	**9**	No results presented	**4**
Other (case study, commentary, unpublished)	**12**		

In the 27 studies meeting final inclusion criteria, 63 individual multivariable models were presented. Outcomes explored in these 63 models included discharge FIM® 33 times[13-29], FIM® gain 20 times[14, 15, 20-22, 25, 30-33], FIM® efficiency 3 times[26, 31], discharge BI 5 times[34-

[38], and BI efficiency twice[38, 39]. The median sample size in all models was 444 (IQR 173 – 561) and, on average, final models included 4.1 (SD 2.5) significant variables.

In the 56 models using FIM® as their outcome, discharge FIM® was the most frequently modelled outcome. The mean R^2 values in identified models of FIM® was 0.65 (range 0.35 to 0.82), 0.22 (range 0.08 to 0.4) and 0.08 (range 0.03 to 0.14) in models of discharge FIM®, FIM® gain and FIM® efficiency respectively. All but 2 of the models of FIM® used some form of linear regression. The remaining 2 models came from the same study[23], where logistic regression was used to assess predictors of discharge FIM® scores <40 and 40-80 compared to >80 as the referent group.

Studies using BI as their outcome were fewer in number than the studies of FIM® and tended to be older. In studies where BI was the dependent variable, mean R^2 values were 0.69 (range 0.61 to 0.78) for discharge BI and 0.26 (range 0.17 to 0.34) for BI efficiency. In the 7 models of BI, 4 used linear regressions, while 3 used a logistic model. Outcomes in the logistic models were <50/100, ≥15/20, and low response (less than one standard deviation below the mean) once each.

In total, 126 candidate variables were explored in the identified models and 63 (50%) of them were found to be a significant predictor at least once. Yet, among variables tested 5 or more times, only 8 were found to be statistically significant predictors of FIM® or BI more than 50% of the time (at $p<0.05$). The most frequently explored variables were stroke characteristics and consequences (Table 2.2), followed by medical history/comorbidities/risk factors/biomarkers (Table 2.3), demographic/ social information (Table 2.4), and processes of care (Table 2.5).

Table 2.2 - Stroke-related candidate predictors of Functional Independence Measure (FIM®) or Barthel Index (BI) at discharge from inpatient rehabilitation explored in a multivariable model, the outcome explored, the ratio of times found significant to times explored, and the direction of effect.

Variable	Overall Significance (%)	Model Outcome (Direction of effect)				
		Discharge FIM®	FIM® Gain	FIM® Efficiency	Discharge BI	BI Efficiency
Admission BI	6/6 (100)	--	--	--	4/4 (mix)	2/2 (mix)
NIHSS	5/5 (100)	2/2 (-)	--	1/1 (-)	2/2 (-)	--
Admission FIM®	46/51 (90)	29/31 (+)	16/19 (mix)	1/1 (NR)	--	--
Dysphasia	4/6 (67)	2/3 (+)	2/3 (+)	--	--	--
Impulsivity	4/6 (67)	2/3 (+)	2/3 (+)	--	--	--
Neglect	4/6 (67)	2/3 (-)	0/1	--	1/1 (-)	1/1 (-)
Hemorrhagic Stroke	9/21 (43)	6/12 (mix)	3/5 (+)	--	0/3	0/1
Impaired Problem Solving	2/6 (33)	1/3 (-)	1/3 (-)	--	--	--
Urinary Incontinence	1/7 (14)	0/2	0/2	--	1/2 (-)	0/1
Variables tested <5 times (sig/times tested): Mini Mental State Exam (2/4), sensory neglect (1/4), L hemiparesis (3/3), R hemiparesis (2/3), Broca's aphasia (1/3), Trunk Impairment Scale (2/2), Postural Assessment Scale (2/2), Abbreviated Mental Test (2/2), Canadian Neurological Scale (1/2), bowel incontinence (1/2), executive function (1/2), physical activity tolerance (1/2), Brunnstrom Arm (1/2), Brunnstrom hand (1/2), right mean cerebral blood flow (1/1), L hemisphere (1/1), respiratory disturbance (1/1), Short Behaviour Scale (1/1), Complication Severity Index (1/1), ideomotor apraxia (1/1), sensation (1/1), R hemiparesis (1/1), number of stroke impairments (1/1), Stroke Impairment Assessment Set (SIAS) – speech (1/1), SIAS – total (1/1)						
Variables never found statistically significant (times tested): Affected side (6), unilateral spatial neglect (5), apraxia (5), visual deficit (5), infarct on CT (4), infarct on MRI (4), ataxia (4), balance (2), attention (2), judgement (2), memory (2), perception (2), duration of sitting (2), mental activity tolerance (2), medical complications (2), Brunnstrom score (2), Brunnstrom upper motor control (2), paralysis (2), lesion distribution (2), lesion location (2), receptive aphasia (1), constructional apraxia (1), lower limb recovery stage (1), hemiparysthesia (1), SIAS - trunk (1), SIAS – sound side function (1), weakness (1), hemianopsia (1), dysarthria (1), visual inattention (1)						

Table 2.3 Medical history, comorbidity, risk factor, and biomarker candidate predictors of Functional Independence Measure (FIM®) or Barthel Index (BI) at discharge from inpatient rehabilitation explored in a multivariable model, the outcome explored, the ratio of times found significant to times explored, and the direction of effect.

Variable	Overall Significance (%)	Model Outcome (Direction of effect)				
		Discharge FIM®	FIM® Gain	FIM® Efficiency	Discharge BI	BI Efficiency
Previous Stroke	5/10 (50)	4/5 (-)	0/2	0/1	1/2 (-)	--
Diabetes	3/10 (30)	2/4 (-)	--	--	1/4 (-)	0/2
Smoker	2/8 (25)	1/3 (+)	1/3 (+)	--	0/2	--
Hypertension	1/9 (11)	1/3 (+)	--	--	0/4	0/2
Variables tested <5 times (sig/times tested): Previous Myocardial Infarction (1/3), Ryle's tube (1/3), pre-stroke modified Rankin Scale (2/2), sum of comorbidities (1/2), pressure ulcer (1/2), Comorbidity Severity Index (1/1), Weighted Comorbidity Index (1/1), diabetes X age (1/1), Parkinson's disease (1/1)						
Variables never found statistically significant (times tested): Etiology (7), pre-stroke BI (4), Charlston Comorbidity Index (4), micro disease on CT (4), micro disease on MRI (4), peripheral artery disease (4), depression (3), serum albumin (2), number of medications (2), ejection fraction (2), plasma homocysteine (2), atrial fibrillation (2), hyperlipidemia (2), previous medical conditions (2), admission laboratory values (2), fractured femur (2), body mass index (1), osteoarthritis (1), hearing impairment (1), urinary catheter (1), aspiration pneumonia (1), seizures (1), valvular heart disease (1)						

Table 2.4 - Demographic and social candidate predictors of Functional Independence Measure (FIM®) or Barthel Index (BI) at discharge from inpatient rehabilitation explored in a multivariable model, the outcome explored, the ratio of times found significant to times explored, and the direction of effect.

Variable	Overall Significance (%)	Model Outcome (Direction of effect)				
		Discharge FIM®	FIM® Gain	FIM® Efficiency	Discharge BI	BI Efficiency
Age	30/45 (67)	16/27 (-)	10/11 (-)	1/1 (-)	2/4 (-)	1/2 (-)
Ethnicity (Non-white)	2/5 (40)	1/1 (-)	1/1 (-)	--	0/2	0/1
Sex (Male)	8/34 (24)	5/20 (mix)	3/7 (mix)	--	0/4	0/2
Variables never found statistically significant (times tested): Living situation (5), marital status (4), vocational status (3), education level (2), caregiver availability (2), occupation (1), occupational prestige (1), handedness (1)						

Table 2.5 - Process of care candidate predictors of Functional Independence Measure (FIM®) or Barthel Index (BI) at discharge from inpatient rehabilitation explored in a multivariable model, the outcome explored, the ratio of times found significant to times explored, and the direction of effect.

Variable	Overall Significance (%)	Model Outcome (Direction of effect)				
		Discharge FIM®	FIM® Gain	FIM® Efficiency	Discharge BI	BI Efficiency
Onset-Admission Interval	8/17 (47)	6/11 (mix)	0/1	1/1 (-)	1/2 (-)	0/2
Variables tested <5 times (sig/times tested): Dopamine receptor antagonist administration (2/2), time from admission to rehabilitation unit to first therapy (1/2)						
Variables never found statistically significant (times tested): Selective Serotonin Reuptake Inhibitor administration (2), phenobarbital administration (2)						

2.4 Discussion

Given the importance of identifying appropriate patients for admission to post-acute inpatient rehabilitation after stroke, it is not surprising that numerous studies have attempted to identify variables that may be useful in this decision-making process. In this review, strict inclusion criteria were used to ensure that only variables available at acute discharge were included and only when they had been used to predict functional outcomes at discharge from rehabilitation. Furthermore, only high quality studies that reported a multivariable model were included to avoid inclusion of potentially confounded binary associations. Nevertheless, 27 studies were identified in total presenting information on 63 separate multivariable models.

Multivariable modeling refers to an array of statistical methods whose primary goal is to minimize the effects of confounding by adjusting for multiple variables simultaneously.[7] Unfortunately, as was the case with the studies identified by this review, multivariable modeling techniques can be used for very different purposes. Some of the identified studies attempted to develop the most parsimonious predictive model possible using the best available information, while others applied multivariable adjustment to control for confounding when exploring the predictive usefulness of an individual variable. This led to differences in the variables explored, the models' predictive accuracies, and the resulting estimates of effect for individual predictors. For this reason, it was decided that the best strategy for compiling this information was to focus on the frequency with which each variable has been tested, the proportion of times it was found to be a significant predictor and the direction of effect. While the most accurate predictive models were able to explain up to 82% of the variation in post-rehabilitation functional outcome, final models tended to consist of relatively few predictors (about 4 on average) and these significant predictors tended to come from a small group of variables.

In the models identified, 126 predictors of BI or FIM® had been explored. Despite the large number of models, only 16 variables were tested in 5 or more models and only 8 of these were found to be significant predictors of either BI or FIM® more than 50% of the times they were tested: admission BI, National Institute of Health Stroke Scale (NIHSS), admission FIM®, dysphasia, impulsivity, neglect, previous stroke, and age. Other variables that showed promise included onset admission interval (OAI), stroke type, and left hemiparesis. In the long list of additional variables tested, many reflect similar constructs to these primary variables, but were defined slightly differently (eg. left hemiparesis, left side affected, and right hemisphere stroke). In the interest of transparency, variables were only pooled when their definitions aligned exactly. However, it is possible that some of these broader constructs may offer additional predictive information and may warrant future exploration.

Not surprisingly, the vast majority of variables tested were related to stroke information or consequences of stroke. Of these, the patient's admission score for the BI or FIM® was the most informative predictor. Barthel Index scores at acute discharge were explored 6 times and remained significant in all models. Admission FIM® scores were explored 26 times as a total score, 6 times as a motor sub score, 6 as a cognitive sub score, and 13 times as individual FIM® items. The total admission FIM® score and cognitive scores remained significant in all models tested, while the motor FIM® was significant in 5 of 6 models. In the only model where motor FIM® was not significant, cognitive FIM® and sphincter sub-scores were also included.[17] Interestingly, admission FIM® scores were always positively correlated with higher discharge FIM® scores, but results for FIM® gain were mixed. Total admission score was negatively correlated with FIM® gain in 6 of 9 models, while cognitive FIM®, self-care, mobility, and social cognition sub-scores were all positively associated with greater FIM® gain in every model tested. These demonstrate opportunities for future research. Still, the frequency with which admission BI and/or FIM® were found to be significant demonstrates their clinical utility and raises concern about possible confounding in models where they were not adjusted for.

The importance of initial functional scores as predictors of future function is not surprising, but results of this review also suggest utility of other clinical variables. Indicators of initial stroke severity such as the National Institute of Health Stroke Scale (NIHSS) and the Canadian Neurological Scale (CNS) were found to be significant on several occasions as were other indicators of post-stroke deficit including impulsivity, neglect, dysphasia, Mini-Mental State Exam (MMSE) scores, and presence of hemiparesis. The utility of these variables likely reflects limitations of the BI and FIM® that can be addressed with the addition of more specific variables. The BI and FIM® are both global measures of function and neither address cognitive issues well. The BI only reflects physical and activity-based deficits, while the cognitive FIM® score has been criticized as being limited in its ability to capture cognitive impairment.[40] In addition, admission scores of BI or FIM® are a snapshot of function that can vary depending on both the initial severity of the stroke and the time since event. This may explain why many of the other stroke consequences that have proven to be significant predictors reflect cognitive/perceptual challenges, specific deficits, and/or initial stroke severity.

In addition to stroke-related information, many studies attempted to account for variables related to the patient’s past medical condition. These included indicators of previous health, chronic medical issues, and stroke risk factors. In general, with the exception of previous stroke, these variables served as poor predictors; this is likely because the deficits in physical and cognitive function that arise from their presence would also be captured by more global measures of function (ie. BI or FIM®). In general, these variables do not appear to be particularly useful in predicting post-rehabilitation function.

As is often the case when multivariable models are developed, demographic and social variables were included in most of the identified models. Of these, only age, ethnicity and sex were found to be statistically significant. Age was strongly correlated with functional outcome and should be included in all models, while sex and ethnicity both demonstrated mixed results and generally poor utility. Although clinically interesting, demographic and social variables often act as proxy measures for concomitant conditions that may or may not be accounted for in statistical models. As examples, older individuals may have more cognitive deficits, more comorbidity, and may experience strokes impacting different regions of the brain than their younger counterparts [41], while female patients are less likely to have an able caregiver.[42] Results from this review suggest that in situations where limited clinical information is available, demographic information (especially age) could be considered when predicting future function.

Although not frequently explored, process indicators represent an interesting group of possible predictors both because of their utility as predictors and their potential for modification. Only 3 process of care variables were found to be statistically significant at least once: onset admission interval (OAI), time from rehabilitation admission to rehab start, and receipt of detrimental drugs in acute care (primarily dopamine receptor agonists). Only OAI (time between stroke onset and rehabilitation admission) was found significant more than twice; predicting FIM® 54% of the time (7/13) and BI 25% (1/4). In these models, OAI was found to be negatively associated with functional outcome in all but one. Studies that explored OAI were conducted in Italy[38], Australia[36], Japan[25], and the USA[26]; which have healthcare systems that differ dramatically. Variations in OAI depend heavily on the system in which the study was conducted, so the diversity in the healthcare systems within which it was explored may explain some of the discrepancies in level of significance and direction of effect. Given their nature, process of care variables in general should be of interest not only to clinicians making decisions about admission to rehabilitation, but also to acute clinicians, policy makers and people involved in guideline development. Further research may be warranted for the process of care variables noted here and other similar indicators.

After years of exploration into variables that can be used to predict function after post-stroke inpatient rehabilitation, data suggest that only a handful are necessary for developing a relatively accurate predictive model. Results of this review suggest that the most successful models are likely to include the patient's age, an indication of stroke severity (the patient's starting point), some measure of function at time of rehabilitation admission (both physical and cognitive), and a process indicator (how they have progressed through acute care). In clinical practice, where decisions need to be made in a timely manner and often with limited information, variables in these areas should be given the most consideration. Studies in this review suggest that age, NIHSS, BI or FIM® assessed at acute discharge, and onset-admission-interval likely offer a good place to start when developing a model to predict functional outcomes after inpatient rehabilitation. Although additional clinical, demographic, and social variables may prove to be useful, measures of general health (ie. previous health state and comorbidities) are not as important as the patient's functional level at acute discharge. Keeping these principles in mind will help clinicians make informed decisions about suitability for admission to inpatient rehabilitation after stroke and to ensure that scarce healthcare resources are used effectively and efficiently.

2.5 Limitations

The models identified by this review included a wide range of variables and were designed with a breadth of purposes in mind. In addition, variation in modeling procedures and reporting of results made it impossible to draw definitive conclusions regarding estimates of effect, beyond direction. For these reasons, it was decided that meta-analysis of estimates of effect was beyond the scope of this review. Future studies to further explore the combined predictive utility of some of the more important predictive variables are warranted.

This review demonstrated a vast literature base in this area. However, this meant that the focus of the review had to be on the most highly predictive variables. Numerous additional variables were identified by this review as significant predictors of function the few times they were explored. Further research into their predictive utility should be performed, while adjusting for the key variables identified in this review.

2.6 Conclusion

In the multivariable models identified by this review the majority of variation in post-rehabilitation function after stroke, as measured by the Barthel Index or the Functional Independence Measure®, can be explained by only a few variables. These include admission functional level (BI or FIM®), National Institute of Health Stroke Scale (NIHSS), dysphasia, impulsivity, neglect, previous stroke, and age. Clinicians making rehabilitation referrals, and decision makers developing policies, should focus on a combination of these variables at this time. Targeted exploration of some of the additional variables identified in this review is also warranted.

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Chapter 3 – A Synthesis of Peer-Reviewed Literature on Team-Coordinated and Delivered Early Supported Discharge after Stroke

3.1 Introduction

The World Health Organization estimates that 15 million people experience a stroke each year, five million of whom are left with permanent disability.[1] Despite an abundance of evidence suggesting that post-stroke rehabilitation can improve patient recovery and reduce disability,[2] debate still remains about where and when these services are best provided. Early supported discharge (ESD), where rehabilitative care is provided in the community as an alternative to remaining in hospital, has gained popularity around the world as a less costly way to rehabilitate moderately and mildly disabled stroke patients. Trials performed to date on ESD suggest that when provided to appropriate patients it can reduce the risk of death or dependency,[3] admission to institutional care,[3] length of hospital stay,[3-6] and the overall cost of services[3, 5, 7] compared to traditional in-hospital rehabilitation. Accordingly, ESD has been included in the Canadian Best-Practice Recommendations for Stroke.[8] If policy makers and healthcare providers hope to adhere to best-practice principles in stroke management, ESD is an essential component.

The most comprehensive review of post-stroke ESD was done by the Cochrane Collaboration® in 2012, who performed pooled analyses of 14 randomized-controlled trials compared to usual care.[3] In this review three forms of ESD intervention were identified: ESD team coordination and delivery, ESD team coordination only, and no ESD team. In their primary outcomes of death, death or institutionalization, and death or dependency, statistically significant differences between ESD and conventional care were only seen among studies where ESD was team-coordinated and delivered, and only in the outcomes of death and institutionalization and death or dependency. However, no pooled description of these studies was provided. The authors of this review noted that further research should be completed to "define the important characteristics of effective ESD services".[3]

In a consensus report on the topic, an international panel of experts on ESD unanimously agreed that specific eligibility criteria for early supported discharge should be used, and that eligibility decisions should be based in part on the patient's level of disability and medical stability.[4] The panel also unanimously agreed that identification of patients suitable for ESD should be made by the ESD team and that flexibility in the criteria is essential. However, the panel did not reach unanimous agreement about what role factors like Barthel Index (BI) scores, ability to transfer from bed to chair, or cognitive function should play in decisions about patient eligibility for ESD.

The objective of this study was to perform a review of the peer-review literature on post-stroke ESD that focused on programs providing best practice care (ie. those that were ESD team-coordinated and delivered). Study inclusion was expanded beyond randomized controlled trials. Information related to the interventions evaluated, the inclusion/exclusion criteria used, the resulting cohort of patients admitted, and the outcomes observed in identified studies was summarized.

3.2 Methods

A systematic review of the literature was performed in three electronic databases (Medline - OVID, Embase - OVID, CINAHL – EBSCO Host) for peer-reviewed journal articles evaluating team-coordinated and delivered post-acute early supported discharge (ESD) programs for post-stroke rehabilitation. Studies published between January 1980 and August 2014 were considered for inclusion. The complete search strategy is presented in Appendix C, but briefly included subject and keyword searches of terms including 'stroke', 'cerebrovascular accident', 'rehabilitation', 'early supported discharge', 'home care services', and 'community care'. Titles and abstracts were reviewed and pertinent studies, systematic reviews and meta-analyses were retrieved. All identified works were reference-searched for additional studies. Studies were included for data extraction if:

- Only patients with primary diagnosis of stroke or cerebrovascular accident were included
- The intervention under study was a team-coordinated and delivered post-acute ESD program for post-stroke rehabilitation defined as follows:
    - ESD team coordinated and delivered programs - identified according to the definition used by the Cochrane Collaboration®[3]
    - Post-acute - programs where the patients under consideration had been admitted to hospital for their acute medical management (ie. not hospital-at-home)
    - Post-stroke rehabilitation - patients included in the intervention would otherwise have been admitted to post-acute in-hospital rehabilitation
- Inclusion/exclusion criteria were reported

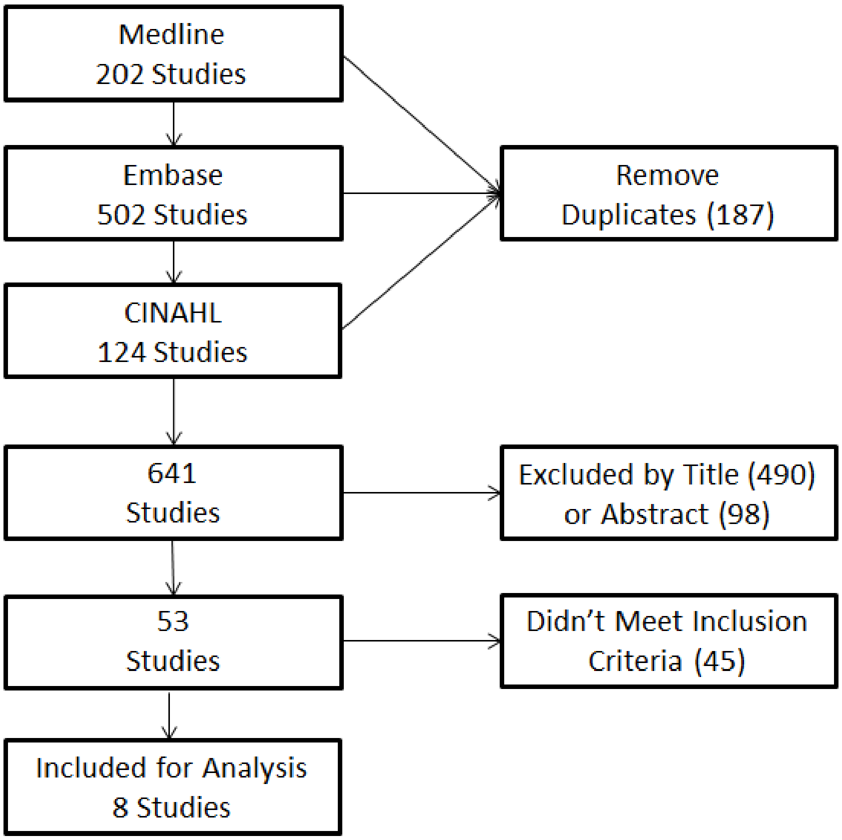
Data extraction consisted of two phases: program description and patient data. Program description included a brief summary of the structure of the ESD program, a description of the control group and a list of the inclusion/ exclusion criteria used to identify suitable candidates. Additional program-specific data included the mean hospital length of stay (HLOS) in the intervention group before discharge, and the proportion of screened patients deemed suitable for ESD (including patients who declined participation but would otherwise have been included).

Extracted patient data began with a description of the cohort included in each trial: mean age, percent female, and proportion with hemorrhagic stroke. This was followed by information on any objective measure of physical, cognitive, social or psychological status assessed within 48 hours of discharge to the ESD program. Finally, all reported outcome measures at the longest period of follow-up were noted along with results of statistical comparison to the control group.

3.3 Results

A flow chart summarizing results from the literature review is presented in Figure 3.1. In total, 641 journal articles were screened. Initially, 490 articles were excluded by title (many articles specifically dealt with cardiac rehabilitation and could be excluded on first glance). Ninety-eight articles were removed based on the abstract alone and 45 after review of the full paper. Of these 45 articles, 13 described an ESD program that was not team coordinated and delivered, post-acute, or an alternative to inpatient rehabilitation. Of the remaining exclusions 12 were reviews, 8 were economic analyses of included trials, 5 were follow-up studies of included trials, 5 did not evaluate an ESD program, 1 was a commentary, and 1 did not include stroke patients. No additional studies were located in the reference lists of the identified reviews. In total, 8 studies were included for further assessment.[6, 9-15]

Figure 3.1 - Flow chart of results from review of studies of team-coordinated and delivered early supported discharge for post-stroke rehabilitation



A summary of the programs explored in the studies of a team coordinated and delivered ESD program is provided in Table 3.1. All teams included a physiotherapist (PT) and occupational therapist (OT) and most included access to a speech language pathologist (SLP). Most teams also included access to a social worker (SW) or nurse. Inclusion and exclusion criteria frequently focused on patients who had physical impairments that could benefit from rehabilitation, but most also included criteria that excluded patients with serious cognitive impairment or comorbidity that would preclude them from benefiting from rehabilitation. All studies also included some form of subjective criteria to allow clinicians an opportunity to exclude patients they judged to be unsuitable. In studies where it was reported, the proportion of acute admissions deemed eligible for ESD ranged from 10-46% with the proportion generally decreasing in more recent studies. The typical period of recruitment into ESD was between 8 and 14 days post stroke with only 2 exceptions. [9, 15] The length of participation in the ESD programs ranged from 30 days to 4 months; however, this was generally shorter in more recent studies (post 2000) where all but one[9] reported ESD duration between 4 and 5 weeks.

Table 3.31 - Summary of program descriptions in identified studies of team-coordinated and delivered post-acute ESD for stroke rehabilitation.

Study/ Year/ Design	Composition of ESD team	Control	Inclusion Criteria	Exclusion Criteria	Patients Included/ Patients Screened	Duration of ESD	ESD Patient HLOS (days)
Anderson 2000[6] (RCT)	Program coordinator (OT), rehabilitation consultant, PT, OT, SLP, SW, rehab nurse	Inpatient rehabilitation, discharge planning and follow-up care as an outpatient or in community	Medically stable, suitable for discharge, suitable home environment, community rehabilitation team available, GP to provide medical care	Subarachnoid hemorrhage, insufficient physical and cognitive function to perform rehabilitation, lack of caregiver consent	112/398 stroke (28%)	5 weeks Median	13 Median
Donnelly 2004[9] (RCT)	Coordinator, OT, PT, SLP, rehabilitation assistant	Hospital Rehabilitation with day hospital follow-up	<4 weeks post stroke, potential to benefit from rehabilitation	Nursing or residential home resident, preexisting disability that precluded rehabilitation	118/896 stroke (13%)	3 months	42 Mean
Holmqvist 1998[10] (RCT)	PT, OT, SLP, SW (consult), coordinator	Routine inpatient and/or day hospital/outpatien t rehabilitation	Acute stroke, Katz ADL A-E, MMSE > 23, Impaired motor capacity (LS) and/or Dysphasia (RAT), no other comorbidity likely to shorten life expectancy	< 5 day HLOS, progressive stroke, subdural hematoma, subarachnoid hemorrhage, massive perceptual deficit, renal/heart/respiratory failure, nonstroke epilepsy, alcoholism, psychiatric disease	86/900 stroke/TIA (10%)	3-4 months	14 Mean
Ljungberg 2001[11] (Non-RCT)	Nurse, nurse's aide, OT, PT, social welfare officer, neurologist	Inpatient Rehabilitation Clinic	Expected rehabilitation time <4 weeks, transfer from chair to bed with 1 person assist	Dementia, dysphagia, cannot communicate via telephone or alarm bell even with assistance of a relative	NR	4 weeks	8 Mean

Mayo 2000[12] (RCT)	Nurse, PT, OT, SLP, dietitian	Usual Care (hospital and community rehab)	Persistent motor deficits, able and willing caregiver	>1 person assist to walk after 28 days post stroke, cognitive impairment (SPMSQ), coexisting conditions affecting independence	194/1542 (13%)	4 weeks	9.8 Mean
Pessah-Rasmussen 2009[13] (Non-RCT)	PT, OT, neurologist (SLP, SW, nurse, neuropsychology when necessary)	Registry-identified non-ESD patients	Need for training in personal or extended activities ADL	Severe pre-stroke dementia, alcohol or drug abuse, unsuitable home conditions, cognitive impairment where insight/ communication lead to safety concerns	NR	1997 – 43 day mean 2005 – 30 day mean	1997 – 18 day Mean 2005 – 10 day Mean
Rodgers 1997[14] (RCT)	Service coordinator (OT or PT), OT, PT, SLP, SW, OT technician	Conventional Care (hospital and community rehab)	Newcastle resident, medically stable, BI 5-19 72 hours post stroke	Residential or nursing home resident, OHS 0-3 prior to stroke, other condition precluding rehabilitation	119/402 (30%)	9 weeks median	13 Median
Rudd 1997[15] (RCT)	PT, OT, SLP, Therapy aide, physician consult	Conventional Care (hospital and outpatient rehab)	Able to transfer independently (if living alone) else with assistance	Lived too far for team to visit	302/660 (46%)	Up to 3 months	34 Mean
ADL – Activities of Daily Living, BI – Barthel Index, ESD – Early Supported Discharge, GP – General Practitioner, HLOS – Hospital Length of Stay, LS – Lindmark Scale, MMSE – Mini Mental State Exam, NR – Not Reported, OT – Occupational Therapist, OHS – Oxford Handicap Scale, PT – Physiotherapist, RAT – Reinvang Aphasia Test, SPMSQ – Short Portable Mental Status Questionnaire, SW – Social Worker, SLP – Speech Language Pathologist, TIA – Transient Ischemic Attack							

A summary of information on the cohort of patients included in the identified trials and the corresponding outcomes is provided in Table 3.2. The average age of patients was approximately 70 years in all trials (range 68-73) and in all but one study[11] there were more men than women included. In studies where it was reported, the majority of patients had experienced ischemic stroke, however, no study explicitly excluded all hemorrhagic patients. A wide variety of functional measures at time of acute discharge were reported across the 8 trials; only 2 of which were reported more than once: Barthel Index (BI) and Mini-Mental State Examination (MMSE). In trials reporting these scores, the mean BI score at discharge was 16/20 and the mean MMSE was 24/30. Rudd et al. reported the most widely dispersed admission scores for both the BI and MMSE and in this study one standard deviation in scores ranged from 11 to 19 in the BI and 14 to 28 on the MMSE.[15] Across all 8 trials, the majority of outcomes were either similar between ESD and the control group or in favour of ESD. Only once was an outcome demonstrated to be significantly better in the control group (1-year anxiety score on the Hospital Anxiety and Depression Scale[15]).

Table 3.32 - Summary of patient populations and outcomes in identified studies of team-coordinated and delivered post-acute ESD for stroke rehabilitation.

Study	Age (Mean)	Female (%)	Hem. Stroke (%)	Patient Variables Measured at Randomization or Discharge (Mean)	Outcome Measures and Results$^{\alpha}$
Anderson 2000[6] (RCT)	72	38	10	All median: BI 85/100, MMSE 28/30, AAP (domestic chores 53/100, household 56/100, service 50/100, social 46/100), GHQ (somatic 5/10, anxiety 4/10, social 8/10, depression 0/10)	6-month: SF-36 (NS), BI (NS), NHP (NS), Satisfaction (NS), AAP (NS), MFAD (NS), Death (NS), Falls (NS)
Donnelly 2004[9] (RCT)	68 Median	NR	NR	BI 14/20, NEADL 6/21, 10 min timed walk 21 sec., EuroQol 59/100, SF-36 physical 35/100, SF-36 Mental 48/100, Quality of Life 17/27	1-year: BI (NS), NEADL (NS), 10-m timed walk (NS), EuroQol (NS), SF-36 Physical (NS), SF-36 Mental (NS), QoL (NS), Patient satisfaction (+), Overall satisfaction (+), Carer strain (NS)
Holmqvist 1998[10] (RCT)	71	46	7	MMSE 27/30, Motor Capacity (arm 50/57, leg 34/36, coordination 8/12, mobility 25/27, balance 15/21, total 131/153), 10m walk test 14 sec (median), neurological score 49/58, aphasia quotient 24/100	3-months: KATZ ADL (NS), BI (NS), FAI (NS), Lindmark motor capacity (+ coordination, others NS), 9-hole Peg Test (NS), 10m walk (NS), Aphasia quotient (NS), Falls (NS), SIP (+ psychosocial, NS others)
Ljungberg 2001[11] (Non-RCT)	72	56	9	FIM (hygiene 4.9/7, bathing 2.1/7, dressing upper 4.8/7, dressing lower 3.7/7, toileting 4.1/7, feeding 5.4/7, transfer chair/bed 4.5/7, transfer toilet 4.8/7, transfer tub shower 2.4/7, locomotion 3.4/7, locomotion stairs 2.5/7, comprehension 5.6/7, expression 5.4/7, problem solving 4.5/7, memory 5.5/7	4-week: modified QPP (+ activity level, staff importance, participation, others all NS)
Mayo 2000[12] (RCT)	70	33	NR	CNS 8.9/11.5, STREAM 82.3/100, TUG 23.3 sec, BI 84.6/100	3-month: SF-36 (+ physical, NS Mental), STREAM (NS), TUG (NS), BI (NS), OARS-IADL (+), RNL (NS)
Pessah-Rasmussen 2009[13] (Non-	73	48	15	’97 Katz ADL (A 6%, B 18%, C17%, D 7%, E 24%, F 7%) ‘05: Katz ADL (A 30%, B 21%, C 13%, D 3%, E 2%, F 4%, G 4%)	No comparison to control reported

RCT)					
Rodgers 1997[14] (RCT)	73 Median	43	NR	BI 15/20 Median	3-months: Survival (NS), Placement (NS), Readmission (NS), NEADL (NS), OHS (NS), WDI (NS), DCGHS (NS), GHQ (NS)
Rudd 1997[15] (RCT)	70	45	NR	BI 15/20, Frenchay aphasia 18/, MMSE 21/30, MI 83/100, 5m timed walk 15 sec, NHP 11/100	1-year: MI (NS), MMSE (NS), FAS (NS), BI (NS), RADL (NS), HADS (- anxiety, NS depression), 5-m timed walk (NS), NHP (NS), CSI (NS)
ADL – Activities of Daily Living, AAP – Adelaide Activities Profile, BI – Barthel Index, CNS – Canadian Neurological Scale, DCGHS – Dartmouth Coop Global Health Status, FAI – Frenchay Activities Index, FAS – Frenchay Aphasia Scale, FIM® - Functional Independence Measure, GHQ - General Health Questionnaire, HADS – Hospital Anxiety and Depression Scale, MFAD – McMaster Family Assessment Device, MMSE – Mini Mental State Exam, MI – Mobility Index, NEADL – Nottingham Extended Activities of Daily Living, NHP – Nottingham Health Profile, OARS-IADL – Older Americans Resource Scale Instrumental ADL, OHS - Oxford Handicap Scale, QPP – Quality from the Patient's Perspective, QoL – Quality of Life, RNL – Reintegration to Normal Living, RADL – Rivermead ADL, SF-36 – Short Form 36, STREAM – Stroke Rehabilitation Assessment of Movement, TUG – Timed Up and Go, WDI – Wakefield Depression Inventory					

[α] Outcomes reported are intervention vs. control comparisons at the longest point of follow-up. Sub-group analyses are not presented. Statistical significance is noted at $p<0.05$ and (+) denotes significantly better in ESD, (NS) no significant difference, (-) significantly better in control

3.4 Discussion

The benefits of ESD for post-stroke rehabilitation have been well documented and team-coordinated and delivered ESD has been identified as the optimal model of care.[3] The objective of this review was to summarize the literature related to one of these ESD programs in order to assist decision makers looking to establish, or refine, a best-practice post-acute ESD program for stroke rehabilitation. This was done by narrowing the focus of our search to team-coordinated and delivered ESD programs described in the peer-reviewed literature and expanding search criteria beyond randomized controlled trials. A total of 8 studies met the inclusion criteria for this review and the summary of program information and patient data demonstrate a number of similarities across studies.

The composition of the ESD teams described in the 8 identified trials was similar. The benefits of a multidisciplinary team post stroke have been well documented[16] and it is evident that they have been recognized as critical components of a coordinated ESD program. All ESD teams included PT and OT as the core of their team and all but one also noted access to SLP. Most teams also included SW or nursing. Patients recovering from stroke (as well as their caregivers) often face challenges with anxiety, depression, and social isolation. One strength of a multidisciplinary rehabilitation team is that they can help patients address medical, physical, cognitive and social issues concomittantly.[16] While therapists support functional recovery,[2] nurses and social workers play an important role in identifying social and emotional challenges and supporting patients as they recover from stroke.[17-19] Social care has been identified as a particular challenge in securing timely discharge to ESD,[20] which further highlights the importance of their inclusion in ESD teams.

In an international ESD consensus statement, experts agreed that decisions about admission to an ESD program after stroke should be made by members of the ESD team using specific eligibility criteria; however, they also noted the need for flexibility in this process.[4] One way to meet this recommendation would be to set evidence-informed inclusion criteria such that all patients meeting all of them are automatically considered for ESD and patients meeting one or more are considered on a case-by-case basis. The inclusion and exclusion criteria (and resulting cohorts of patients) in the studies identified here offer a few examples of criteria that may be useful in this decision making process. In general, the criteria used by the studies identified in this review target patients with mild-to-moderate functional impairment, good cognitive function, potential to benefit from rehabilitation, and those who live in a suitable environment for rehabilitation.

The benefits of ESD have been most consistently demonstrated among patients with mild-to-moderate functional impairment. In Cochrane's review, a BI of 10-20 was used to identify mild-to-moderate impairment;[3] however the studies identified here suggest that team-coordinated ESD programs are admitting patients with an average BI of 16/20. The study with the most widely dispersed admission scores was Rudd *et al*.,[15] where one standard deviation from the mean was still between 11 and 19 on the BI. Admission criteria for ESD could focus on patients with a BI of 16-20, but should not exclude patients with BI of 10-15. Future research should also explore differences in adjusted outcomes between patients with BI of 10-15 and 16-19.

In the studies identified here, nearly all noted cognitive function in their inclusion/exclusion criteria stating concerns for both the patient's ability to participate in rehabilitation and their safety at home. Holmqvist et al. explicitly used an MMSE score of 23 in their inclusion criteria[10] and two others reported average admission scores of 28 and 21 respectively.[6, 15] In these 3 studies, the mean score on admission was 24/30. Similar to BI, the study with the widest dispersion of admission MMSE scores was Rudd et al.,[15] where one standard deviation from the mean ranged from 14 to 28. A measure of cognitive function should be included in admission criteria for ESD alongside physical function. Focus could be placed on patients with scores of 23-30, as was done by Holmqvist, while identifying patients with scores of 14-22 for further consideration. No study to date has compared outcomes between patients with high or low cognitive function explicitly and more research in this area is also warranted.

In addition to patient characteristics, many of the identified studies also included reference to practical considerations such as the availability of a caregiver, suitability of the home environment, and proximity to the hospital. While caregiver availability has been demonstrated to play a significant role in patient recovery after stroke,[21, 22] suitability of the home environment and proximity to the hospital also represent interesting practical considerations. Flexibility in care provision is regularly mentioned as being important by ESD experts.[4, 20] Although a patient may meet all of the characteristics of a typical ESD candidate, few clinicians would feel comfortable discharging patients to an unsuitable home environment (or no home at all). In these cases the best interest of the patient should be the most important factor in decisions regarding ESD suitability. Care should be taken to document these instances so that they can be studied in detail and analyses can be adjusted appropriately during program evaluation. In a similar way, the distance to a patient's home may practically exclude them from ESD in some instances. Provision of ESD in rural settings has been demonstrated to be effective[23] even though care was not coordinated and delivered by the ESD team. Decision makers may feel the need to adjust for their specific regional context when designing an ESD program and should not be afraid to search out innovative solutions built on the basic principles of best-practice ESD. More research is needed in these rural and remote settings as well.

Based on these criteria, an algorithm for admission to ESD could be developed as follows. Patients with a BI of 16-20, MMSE 23-30, and a suitable home environment within a pre-determined reasonable distance from the hospital could have a discharge to ESD initiated automatically. Patients with a BI of 11-20 and an MMSE of 14-30 could be flagged for clinical assessment for suitability for admission to ESD, while all other patients could be considered on a case-by-case basis. This type of system might help to smooth the transition of appropriate patients to ESD and improve system efficiency, while still allowing an appropriate level of flexibility in the admission process.

In addition to clinical decision making, the results of this review may also be useful for individuals involved in capacity planning for ESD. An ESD program that is too small will not be able to meet the needs of all patients who could benefit from its services, while a program that is over-sized can be seen as a waste of resources. In the studies identifies here, the proportion of screened patients who were deemed suitable for admission to ESD ranged from 10% to 46% and the duration of ESD ranged from 30 days to 4 months. Interestingly, both of these dropped over time. Studies published since 2000 have included a weighted average of 15% of acute stroke survivors in their ESD programs and, with the exception of the study by Donnelly et al,,[9] the mean duration of ESD in studies published since 2000 was between 4-5 weeks. Pessah-Rasmussen et al.[13] specifically noted that in their program the mean duration of care dropped from 43 days in 1997 to 30 days in 2005. These trends likely demonstrate a subtle, but important, shift in thinking around ESD. Based on the results of this review, the authors suggest that decision makers anticipate approximately 15% of stroke survivors as candidates for ESD and consider 4-5 weeks as a reasonable average duration of care for planning purposes.

Team-coordinated and delivered ESD after stroke is an important component of an effective stroke rehabilitation system. Cochrane's ESD trialists and Fisher's consensus statement have established a strong foundation with which ESD providers can make informed decisions about program development. This study focused on the way ESD programs are applying this research around the world and to offer some perspective on the evolution of ESD care after stroke. Summary of this information may be helpful to healthcare providers looking to develop or evaluate a regional ESD program. It may also be helpful in informing future research into the topic so that we continue to understand the nuances of providing ESD. This will help to ensure that we continue to provide effective ESD to meet the needs of our patients and provide value for our healthcare systems.

3.5 Limitations

In the studies identified by this review, the admission criteria and functional outcomes reported were too heterogeneous to allow for any statistical comparison to be performed. For this reason, results focused on a summary of published admission criteria as an indicator of clinical judgment. Future research is necessary to explore the relationship between the variables used to select patients for ESD and the functional outcomes they achieve.

3.6 Conclusions

Team-coordinated and delivered ESD after stroke is an effective way to provide rehabilitation to moderately and mildly impaired patients. Detailed review of ESD programs providing team-coordinated and delivered care suggests some meaningful similarities that can be useful to ESD clinicians and decision makers planning to develop or evaluate an ESD program. Studies suggest that inclusion criteria for ESD should include an objective measure of both physical and cognitive function. Barthel Index scores of 16-19 and a Mini Mental State Examination Score greater than 23 could be considered as near-automatic criteria for admission assuming caregiver availability, suitability of the home environment and proximity to the hospital are also favourable. Capacity planning for ESD can begin by assuming that approximately 15% of stroke survivors will be ESD candidates and that they will require services for 4-5 weeks on average. However, flexibility in program planning and ongoing evaluation are recommended and should be incorporated into future research.

3.7 Reference List

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Chapter 4 – Exploring the Relationship between Resource Availability and Patterns of Discharge to Inpatient Rehabilitation after Stroke: A Multi-level Cohort Analysis

4.1 Introduction

Stroke is a leading cause of death and disability in Canada affecting approximately 50,000 Canadians annually.[1] Ontario, Canada's most populous province, accounts for approximately 40% of these incident cases[2] and research in the province suggests that between 37%[3] and 43%[2] of stroke survivors in Ontario have rehabilitation needs that are appropriate for discharge to inpatient rehabilitation. No clearly defined criteria for rehabilitation suitability have been established, however, and international research suggests that decisions about referral to inpatient rehabilitation after stroke often differ between clinicians and across organizations.[4, 5]

Ontario covers an area of over one million square kilometers with diverse population density ranging from large cities to remote rural outposts. Planning and coordination of healthcare services, therefore, must overcome unique challenges in every region of the province. In 2004, work was initiated by Ontario's government to divide the province into smaller, more homogeneous regions called Local Health Integration Networks, and in 2007 the LHINs took over responsibility for planning, integrating and funding regional healthcare.[6] These 14 LHINs represent an opportunity for evaluations of regional healthcare delivery within a single-payer universal healthcare system. The LHIN boundaries represent geographically distinct regions of the province that can be used to assess geographic variations in healthcare provision both in the absence of explicit region-based planning prior to 2007 and with regional governance since.

While Ontario data suggest that access to inpatient rehabilitation is increasing at the population level, the proportion of stroke patients admitted to inpatient rehabilitation after acute care still ranged from 24% to 39% across Ontario's LHINs in 2011 [2]. However, no research has been performed to test if this variation is an appropriate reflection of patient needs, or an indication of unequal access to services. An association between the availability of regional rehabilitation beds and patterns of discharge to inpatient rehabilitation after stroke has been demonstrated in other jurisdictions[7], but this has not been formally tested in Canada.

The objective of this study was to explore the relationship between the availability of stroke rehabilitation resources and patterns of discharge to inpatient rehabilitation after stroke. It was hypothesized, *a priori,* that in Ontario, the probability of being referred to inpatient rehabilitation after stroke varied between LHIN regions, after adjusting for patient-level characteristics. It was further hypothesized, *a priori,* that a significant proportion of this variation could be explained by variation in the availability of inpatient rehabilitation resources.

4.2 Methods

This was a cohort study of patients admitted to acute care in Ontario, Canada with a primary diagnosis of stroke. The goal of the study was to use LHIN boundaries to explore variation in regional patterns of discharge to inpatient rehabilitation after stroke, while controlling for differences in regional patient populations. Because patients are nested within LHINs, a multi-level modelling approach was adopted. Study methods met all requirements of the Health Sciences Research Ethics Board at Western University (Appendix D). All patient-level data were maintained and analyzed at the Institute for Clinical Evaluative Sciences, Toronto, Ontario in accordance with their institutional ethics standards and protocols.

Patient data were drawn from three sources: the Discharge Abstract Database (DAD), the National Rehabilitation Reporting System (NRS), and the Ontario Stroke Audit (OSA). The DAD collects information on all patients admitted to an acute care hospital in Canada and reporting is mandatory for all acute hospitals in Ontario. The NRS collects information on patients admitted to designated rehabilitation beds across Canada and reporting to the NRS is mandatory for Ontario hospitals with designated rehabilitation beds. Both databases contain demographic, clinical, and administrative data for each patient admission. The DAD and NRS were used in this study to capture data on the number of acute stroke discharges and admissions to inpatient rehabilitation respectively by residents of each LHIN region. Both the DAD and NRS are maintained by the Canadian Institute for Health Information (CIHI).[8]

The OSA was the primary source of data in this study. The OSA is a biennial chart audit of Emergency Department (ED) and acute care data from all hospitals in Ontario admitting more than 10 patients with stroke (pediatric and psychiatric hospitals excluded).[9] Each audit represents a random sample of approximately 20% of eligible ED and acute stroke admissions. At each facility, chart audits were performed by trained abstractors and entered into an extraction software program that performed automatic checks for completeness and internal consistency of data. Categorical variables with 'yes' or 'no' options (e.g. previous stroke) were coded 'yes' if mentioned anywhere in the chart and 'no' otherwise. Continuous and multiple-response categorical variables required direct data entry to ensure completeness of data collection. The only variable for which missing data was allowed was the modified Rankin Scale (mRS). If no mRS was recorded in the chart, the mRS score was coded as missing.

Two cohorts were formed using OSA data: fiscal years 2004/05 and 2008/09 (no audit was performed in 2006/07). Because the LHINs weren't formally established until 2007, the retrospective application of LHIN boundaries within the 2004/05 cohort was performed to allow consistency in comparison with the 2008/09 cohort. Patients from the 2004/05 and 2008/09 cohorts were assigned to a LHIN region based on the postal code of their primary residence. Patient records were included only if the patient was admitted to an acute care hospital in Ontario and had a primary diagnosis of stroke as designated by International Classification of Disease (version10) codes: H34.1, I60 (excl. I60.8), I61, I63 (excl. I63.6), or I64.

The outcome of interest in this study was discharge destination after acute care as recorded in the OSA. Discharge destination was classified as a dichotomous variable: inpatient rehabilitation vs. other (home, retirement home, complex continuing care, long-term care, other). The explanatory variable of interest in this study was a per-patient estimate of the availability of inpatient rehabilitation beds to stroke survivors from each LHIN region. For each LHIN region, the number of residents admitted to inpatient rehabilitation with a primary diagnosis of stroke was retrieved from the NRS and multiplied by their mean length of stay. The result was an estimate of the total number of inpatient rehabilitation bed days occupied by patients with stroke from each LHIN region in each cohort (2004/05 and 2008/09). This estimate was then divided by the number of patients discharged alive from acute care with primary diagnosis of stroke in each LHIN region in each cohort year, as captured by the DAD. The resulting indicator was a LHIN-region estimate of the number of inpatient rehabilitation bed days available per acute stroke discharge.

Patient-level covariates drawn from the OSA represented five groups of variables: demographic data, previous medical history, clinical information on admission, in-hospital procedures/complications, and clinical information on discharge. Demographic variables explored were age, sex, smoking status, previous living arrangement (alone or with others), and type of residence. Previous medical history variables included previous stroke, previous transient ischemic attack (TIA), asthma, dementia, depression, level of independence, diabetes, hypertension, hyperlipidemia, chronic congestive heart failure/pulmonary edema, carotid procedure (endarterectomy or stent), cancer, renal disease, peripheral vascular disease, atrial fibrillation, and coronary artery disease. Admission data included Canadian Neurological Scale score (CNS), stroke type, and level of consciousness. In-hospital procedure/complication variables included new onset atrial fibrillation, pneumonia, swallowing screen completion, nasogastric tube insertion and feeding tube insertion. The only discharge variable was modified Rankin Scale score (mRS).

The majority of covariates were categorical and were entered into the models directly as collected. The only continuous variable available was age and it was modelled as such. There were also two ordinal measures of patient function collected: the Canadian Neurological Scale (CNS) and the modified Rankin Scale (mRS). These were divided into previously defined clinically significant groups and modelled categorically.

The CNS is a standardized assessment of the neurological status of alert or drowsy patients shortly after acute stroke.[10] The CNS assesses motor function and alertness and is scored on a scale from 0 to 11.5, where higher numbers denote higher function. In tests of reliability, the CNS demonstrated adequate internal consistency (Cronbach's α=0.792) and adequate to excellent inter-rater reliability (kappa statistics ranging from 0.535-0.835).[11] It's items have also demonstrated excellent convergent validity relative to a comprehensive neurological exam (r= 0.664-0.769).[11] In this study CNS scores were divided into 3 categories: 0-3, 4-8 and >8. Patients who were unconscious on arrival were assigned a CNS score of 0.

The mRS is a measure of functional independence assessed at discharge from acute care[12]. The measure has been demonstrated to have reasonable reliability when performed in direct observation of patients with stroke (weighted kappa for inter-rater reliability ranging from 0.72-0.93).[13] It has also demonstrated good concurrent validity compared with the Barthel Index (r=-0.81) and the Frenchay Activities Index (r=-0.80).[14] In the mRS, patients are assigned a score of their functional independence relative to previous function ranging from 0 to 5 with lower scores indicating greater function. In this study, mRS scores were dichotomized into three groups: 0-2, 3-5, and missing.

Data were retrieved separately for 2004/05 and 2008/09. Differences in patient-level variables between cohorts were explored using Chi Squared tests and t-tests as appropriate. Multi-level models were developed separately for each cohort with discharge to inpatient rehabilitation as the dependent variable. To identify significant patient-level variables, exploratory multi-level logistic regression models were established including LHIN-region of residence as the random intercept and all patient-level covariates as fixed effects. Patient-level covariates significant at $p<0.2$ were then included in a refined model to test for significant variation in random intercepts between LHIN regions and the variance partition coefficient was calculated to estimate the proportion of total variation attributable to LHIN of residence. Finally, if significant variation in the random intercept remained, the variable for rehabilitation bed days per stroke was entered as a LHIN-level explanatory variable. All models were developed in SAS v 9.2 using the GLIMMIX procedure (sample code is presented in Appendix E and model output are presented in Appendix F).

4.3 Results

The 2004/05 and 2008/09 audits included data from 5,032 and 4,363 patients respectively; of these, 2,000 and 1,726 patients were eligible for inclusion in this study after excluding patients not admitted to an acute bed (ED only) and TIAs. Descriptive statistics from the two cohorts are presented in Table 4.1.

Table 4.31 - Description of the cohorts of patients included in the multi-level model from the 2004/05 and 2008/09 Ontario Stroke Audits

Variable		2004/05 Audit	2008/09 Audit	P-Value
Number of eligible patients		2000	1726	--
Age (mean, SD)		73.9 (13.1)	72.7 (13.7)	0.007
Sex	Female vs. Male	1025 (51%)	849 (49%)	0.210
Previous living arrangement	Alone	473 (23.7%)	390 (22.6%)	<0.001
	With others	1464 (73.2%)	1231 (71.3%)	
	Undetermined	63 (3.2%)	105 (6.1%)	
Place of Residence	Home vs. other	1504 (75.2%)	1239 (71.8%)	0.018
Previous Stroke		515 (25.8%)	398 (23.1%)	0.057
Previous TIA		257 (12.9%)	213 (12.3%)	0.641
Asthma		225 (11.3%)	202 (11.7%)	0.665
Dementia		196 (9.8%)	161 (9.3%)	0.625
Depression		209 (10.5%)	164 (9.5%)	0.336
Pre-Event Status	Indep. vs. dependent	1477 (73.9%)	1409 (81.6%)	<0.001
Diabetes		548 (27.4%)	417 (24.2%)	0.024
Hypertension		1324 (66.2%)	1142 (66.2%)	0.982
Hyperlipidemia		583 (29.2%)	642 (37.2%)	<0.001
Smoking History	Current	325 (16.3%)	277 (16.0%)	0.877
	Former	302 (15.1%)	271 (15.7%)	
	Non-Smoker	1373 (68.7%)	1178 (68.3%)	
Pulmonary Edema		158 (7.9%)	141 (8.2%)	0.763
Carotid Interventions		37 (1.9%)	27 (1.6%)	0.503
Cancer		229 (11.5%)	130 (7.5%)	<0.001
Renal Disease		17 (0.9%)	78 (4.5%)	<0.001
Cirrhosis		17 (0.9%)	6 (0.3%)	0.051
Peripheral Vascular Disease		117 (5.9%)	81 (4.7%)	0.116
Atrial Fibrillation		335 (16.8%)	301 (17.4%)	0.577
Coronary Artery Disease		596 (29.8%)	426 (24.7%)	<0.001
Canadian Neurological Scale	0-3	98 (4.9%)	100 (5.8%)	<0.001
	4-8	610 (30.5%)	410 (23.8%)	
	>8	1292 (64.6%)	1216 (70.5%)	
Stroke Type	Ischemic	1612 (80.6%)	1372 (79.5%)	0.017
	Sub-arachnoid Hem.	42 (2.1%)	57 (3.3%)	
	Intra-Cerebral Hem.	142 (7.1%)	148 (8.6%)	
	Undetermined	204 (10.2%)	149 (8.6%)	
Level of consciousness	Alert vs. other	1766 (88.3%)	1567 (90.8%)	0.014
Swallowing Screen		1021 (51.1%)	1025 (59.4%)	<0.001
Atrial Fibrillation		335 (16.8%)	301 (17.4%)	0.577
Pneumonia		64 (3.2%)	63 (3.7%)	0.450
Nasogastric Tube		143 (7.2%)	134 (7.8%)	0.477
Feeding Tube		63 (3.2%)	67 (3.9%)	0.225
Modified Rankin Scale Score	0-2	683 (34.2%)	713 (41.3%)	<0.001
	3-5	1295 (64.8%)	976 (56.5%)	
	Missing	22 (1.1%)	37 (2.1%)	
Discharge Destination	Rehabilitation	622 (31.1%)	589 (34.1%)	<0.001
	Home	970 (48.5%)	847 (49.1%)	
	Retirement Home	38 (1.9%)	39 (2.3%)	
	Complex Continuing Care	22 (1.1%)	51 (3.0%)	
	Long-Term Care	297 (14.9%)	176 (10.2%)	
	Other	51 (2.6%)	24 (1.4%)	

Adjusting for patient-level variables, significant variation in the proportion of patients admitted to inpatient rehabilitation after stroke (random intercept) was noted in 2004/05 and 2008/09 (p=0.021 and 0.045 respectively). The proportion of variation in discharge to rehabilitation attributable to LHIN of residence was 8% in 2004/05 and 4% in 2008/09. After inclusion of rehabilitation bed days per stroke in the models, significant variation in both random intercepts remained (Table 4.2). Resource availability demonstrated a statistically significant effect in 2004/05 (Table 4.3) but not in 2008/09 (Table 4.4). Adjusted odds ratio estimates for the two cohorts were 1.06 and 1.03 for 2004/05 and 2008/09 respectively. This suggests that a 1 day increase in the average number of rehabilitation bed days available per stroke survivor was associated with a 6% and 3% increase in the probability of discharge to inpatient rehabilitation respectively in the two cohorts.

Table 4.32 - Variance parameter estimates for multi-level models of discharge to inpatient rehabilitation after stroke, adjusting for significant patient-level variables and rehabilitation availability in the 2004/05 and 2008/09 Ontario Stroke Audits.

Variable	Estimate	Standard Error	p-value
2004/05 Cohort			
Rehabilitation Admissions by LHIN	0.186	0.101	0.032
2008/09 Cohort			
Rehabilitation Admissions by LHIN	0.125	0.074	0.047

Table 4.33 - Solutions for fixed effects in the multi-level model of discharge to inpatient rehabilitation after stroke, adjusting for significant patient-level variables and rehabilitation availability in the 2004/05 Ontario Stroke Audit.

Variable		Odds Ratio	95% CI	P-Value
Age (mean, SD)		0.99	0.98-1.00	0.23
Previous living arrangement	With others vs Alone	0.72	0.54-0.95	0.04
	Undetermined vs. Alone	0.53	0.24-1.17	
Pre-Event Status	Independent (vs. dependent)	2.10	1.52-2.90	<0.001
Arrived From	Other vs. Home	0.70	0.51-0.96	0.03
Asthma	Yes vs. No	0.65	0.43-0.98	0.04
Dementia	Yes vs. No	0.27	0.16-0.47	<0.001
Depression	Yes vs. No	0.58	0.37-0.89	0.02
Cancer	Yes vs. No	0.76	0.52-1.12	0.15
Canadian Neurological Scale	4-8 vs. 0-3	1.51	0.76-3.02	0.12
	>8 vs. 0-3	1.18	0.58-2.42	
Stroke Type	Ischemic vs. ICH	0.90	0.58-1.39	0.02
	SAH vs. ICH	1.54	0.49-4.85	
	Undetermined vs. ICH	0.43	0.23-0.82	
Level of consciousness	Other (vs. Alert)	0.58	0.34-1.01	0.05
Swallowing Screen	Yes vs. No	1.72	1.31-2.26	<0.001
Modified Rankin Scale Score	3-5 vs 0-2	14.82	10.15-21.64	<0.001
	Missing vs. 0-2	4.71	1.44-15.45	
Rehab Bed Days per Stroke		1.06	1.01-1.11	0.02

Table 4.34 - Solutions for fixed effects in the multi-level model of discharge to inpatient rehabilitation after stroke, adjusting for significant patient-level variables and rehabilitation availability in the 2008/09 OSA.

Variable		Odds Ratio	95% CI	P-Value
Age (mean, SD)		0.98	0.97-0.99	0.001
Previous living arrangement	With others vs Alone	0.74	0.54-1.01	0.07
	Undetermined vs. Alone	1.17	0.64-2.15	
Pre-Event Status	Independent (vs. dependent)	2.54	1.72-3.75	<0.001
Asthma	Yes vs. No	0.66	0.42-1.03	0.06
Dementia	Yes vs. No	0.19	0.11-0.34	<0.001
Hypertension	Yes vs. No	1.29	0.95-1.75	0.10
Pulmonary Edema	Yes vs. No	1.16	0.71-1.89	0.54
Peripheral Disease	Yes vs. No	1.49	0.79-2.80	0.20
Stroke Type	Ischemic vs. ICH	0.89	0.58-1.38	0.001
	SAH vs. ICH	0.34	0.12-0.97	
	Undetermined vs. ICH	0.25	0.11-0.53	
Level of consciousness	Other (vs. Alert)	0.67	0.42-1.08	0.10
Swallowing Screen	Yes vs. No	1.68	1.24-2.27	0.003
Feeding Tube	Yes vs. No	0.35	0.18-0.66	0.004
Modified Rankin Scale Score	3-5 vs 0-2	18.33	13.03-25.79	<0.001
	Missing vs. 0-2	3.56	1.41-9.02	
Rehab Bed Days per Stroke		1.03	0.98-1.07	0.21

4.4 Discussion

The objective of this study was to test for regional variation in access to rehabilitation and to explore the relationship between the availability of stroke rehabilitation resources and patterns of discharge to inpatient rehabilitation after stroke across Ontario. In both cohorts, variation in the proportion of LHIN-region residents referred to inpatient rehabilitation was confirmed using a hierarchical model. However, the ability of rehabilitation resources to explain this variation demonstrated mixed results, explaining a significant proportion in 2004/05 but not in 2008/09. These findings may have important implications for stroke system design and health policy development in Ontario.

A wealth of research has demonstrated the importance of rehabilitation in helping patients recover physical and cognitive function after stroke, while also improving social participation and quality of life.[15] Accordingly, best-practice recommendations in Canada,[16] and around the world,[17] endorse inpatient rehabilitation for patients with moderate and severe impairments after stroke. Unfortunately, research has also demonstrated that post-stroke rehabilitation receives less attention and investment compared to primary prevention and acute management.[18] When difficult budgetary decisions need to be made, rehabilitation resources are often cut first; which may partly explain why no LHIN in Ontario has met the Ontario Stroke Network's benchmark of 43% admission to inpatient rehabilitation.[2] Not only is this troubling from the perspective of the patients who are failing to receive the evidence-based care they need, but also from the perspective of the system where investment in inpatient rehabilitation can have a number of positive impacts. As an example, a previous study of Ontario data found that discharge to inpatient rehabilitation significantly reduced mortality (p=0.01) and Long-Term Care (LTC) discharges (p=0.01) among severely impaired stroke patients (mRS 4-5) when compared to propensity-matched controls cared for in other settings.[19]

The weighted rehabilitation bed day indicator used as the explanatory variable in this study was chosen to represent a reasonable indicator of the availability of regional post-stroke rehabilitation. Previous studies have demonstrated an association between *per-capita* rehabilitation beds and post-stroke admissions to rehabilitation,[7] but this assumes that patients with stroke have equal access to these beds in all regions. In Ontario, very few rehabilitation facilities have dedicated beds for stroke care and most report operating at or near capacity.[19] Patients with stroke are in constant competition with other patient populations for scarce resources, so bed occupancy was felt to provide a better indication of the number of bed equivalents available to stroke survivors for rehabilitation.

Although increasing access to inpatient rehabilitation is positive for appropriate patients, efficient utilization of resources is also critically important. Unfortunately, Ontario-based research has demonstrated concerns with how inpatient rehabilitation resources are being utilized across the province.[2, 3] No LHIN in Ontario has achieved the OSN's target of 43% admission to inpatient rehabilitation[2], and one Ontario study noted that length of stay in inpatient rehabilitation after stroke may be excessively long in some instances.[20] Bed occupancy can vary both as a function of increased rates of admission (which could be seen as positive in Ontario) or longer length of stay (negative in Ontario). In the models presented here, the estimated effects of rehabilitation availability on the adjusted odds of being discharged to inpatient rehabilitation were positive in both cohorts (although only significantly so in 2004/05). These estimates suggest a relationship between more bed days and more admissions; however, further research is necessary to confirm these findings. The difference in significance between the two cohorts also requires further examination as does the relationship between resource availability and length of stay.

Despite the mixed results found for the relationship between resources and discharges, variation in discharge practices were noted across LHINs in each cohort. Traditionally, comparisons between regions in Ontario have been performed using ecologic-level data, which do not permit adjustments for patient-level variation. Multi-variable models have been used to address this issue by adjusting for patient characteristics while including regional indicators;[7] however, they do not account for the nested nature of the data. The multi-level approach adopted here accounts for both variation in regional patient populations and the hierarchical nature of the data. As health information technology becomes more sophisticated, and data more readily available, multi-level techniques should be considered more frequently. While careful consideration must be given to the level of analysis (as the number of groups included in a hierarchical model can impact the power of the statistical inferences), these techniques offer the opportunity for more appropriate and in-depth exploration of regional care.

In Ontario, the 14 LHIN regions offer just enough groups to justify a multi-level approach, but also raise concerns about type II errors. Policy makers in Ontario must be cautioned against ignoring findings that fail to reach statistical significance when comparing across LHINs, but should also be alerted to the enhanced importance of statistically significant results. In all multi-level research (and other areas where sample sizes are a concern), careful consideration of the size of the estimates of effect (and confidence limits) should be undertaken in addition to statistical inferences such as p values. Presentation of results in this was will allow all parties to have meaningful discussion regarding research findings and their potential implications. The results of this study highlight several opportunities for future research. First, this study was not designed to formally test the impact of LHIN formation on access to services, but the differences noted between the pre and post-LHIN time periods are noteworthy. At study onset, the 2004/05 and 2008/09 OSAs were the two most recent audits available and the LHIN boundaries represented either an imminent or a recently enacted division of Ontario's geography into healthcare regions. Specific differences between the two cohorts were not hypothesized, but the fact that the effect of resource availability on discharge to rehabilitation has diminished since the LHINS were formed (as well as the proportion of variation explained at the LHIN level) suggest that LHINs may have had a positive impact on the equity of access to post-stroke inpatient rehabilitation across the province. Ontario Stroke Audit data are now available for 2002/03 and 2010/11, which could be used to further test this hypothesis.

Second, this study raises questions about the source of the variability in the availability of rehabilitation resources between LHINs. The site of rehabilitation was not considered in any of the analyses here, meaning that patients could have received their rehabilitation in any LHIN region. In many instances, it may be appropriate for patients to travel out-of-LHIN for rehabilitation and this may be an advantageous strategy for a LHIN trying to increase access to specialized stroke rehabilitation for its residents. Future research should explore how frequently this occurs and what impact it has on patient recovery. Alternatively, the variation in resource availability may have arisen from differential investments in stroke rehabilitation across LHIN regions, whether independently or at the expense of other patient groups. A between-LHIN comparison of the relative number of rehabilitation beds *per capita* and the proportion of total rehabilitation bed days occupied by patients with stroke would help inform LHINs about whether high achieving regions have more rehabilitation resources for stroke, different priorities for admission, or both.

Finally, in order to test the LHIN-level hypotheses in this study, patient-level data were modelled as fixed effects in all analyses. Future research could also be performed, using the same data, to explore variation in referral patterns between LHINs while adjusting for differences in the availability of services. Numerous studies of the relationship between patient-characteristics and discharge to post-stroke rehabilitation have been undertaken, as have studies of predictors of functional gain during rehabilitation[21]. Comparison of these studies demonstrated differences in how patient variables were used for selection for inpatient rehabilitation between studies and in different parts of the world. To the best of our knowledge, no study has explicitly tested for regional variation in clinical decision making using a multi-level model. This work could help inform discussion about differences in clinical decision-making criteria between regions, which may help practitioners and researchers move closer to developing standardized admission criteria for post-stroke rehabilitation.

4.5 Limitations

Although Ontario's LHIN regions offer an excellent opportunity for between-region comparison, the relatively small number of LHINs presented a challenge in adjusting for region-level covariates because the number of LHINs becomes the effective sample size. Combining data from multiple audits could be performed in future analyses to address this issue, but would require the assumption that each LHIN in each year is a statistically independent observation. Since the LHINs were officially established in 2007, this assumption would not have been valid for the data used in this study. As mentioned previously, the 2002/03 and 2010/11 audits now offer opportunities for further exploration.

Despite the benefits of a large data set like the OSA, there were some limitations associated with its use. Since the OSA had been previously completed, analyses performed here were restricted to the data available and the methods by which they were retrieved. The corresponding set of variables excluded some information that would have been useful. Age, an indicator of stroke severity, and a measure of function have been suggested as the most important patient-level variables to adjust for when modelling rehabilitation suitability.[21] In studies that included a measure of function, discharge BI and or FIM® were the most frequently significant measures. While age and CNS score were available in the OSA, the only indicator of function at discharge was the mRS, which reflects physical function only and has been criticized for its lack of sensitivity.[22] Inclusion of the Functional Independence Measure FIM® would have provided a more sensitive measure of physical ability and a measure of cognitive function. Despite this limitation, the mRS was by far the most significant predictor of discharge to rehabilitation in the OSA data (confirming previous findings) and presence of dementia was available to account for some cognitive impairment in both models.

The OSA data were also collected retrospectively using a chart audit, which often relied on physician notes written while taking the patient's history. This raises concerns about measurement that may have led to underestimation of the prevalence of some variables. The concern over measurement bias was of primary concern for the demographic and previous medical history variables that were coded as yes or no based on any mention in the chart. However, this was believed to be a minor limitation as there is no reason to believe that this potential bias would differ between LHIN regions.

4.6 Conclusion

In Ontario, Canada, diverse geography contributes to unique regional challenges in provision of inpatient rehabilitation after stroke. The methods used here demonstrate the feasibility of using a multi-level strategy for system evaluation and, when adjusting for variation in regional patient populations, significant variation in the proportion of patients referred to inpatient rehabilitation between LHIN regions was demonstrated in fiscal years 2004/05 and 2008/09. However, the availability of rehabilitation resources demonstrated mixed results in accounting for this variation. These findings confirm regional variation in access to post-stroke rehabilitation across Ontario and provide evidence to support further research into the potential for targeted investments in inpatient rehabilitation to reduce this variation.

4.7 Reference List

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Chapter 5 – Exploring the Impact of In-home Rehabilitation Resources on Avoidable Admissions to Inpatient Rehabilitation after Stroke: An Ecological Study

5.1 Introduction

Approximately 40% of all strokes and transient ischemic attacks (TIAs) in Canada occur in the province of Ontario[1] leading to roughly 20,000 patients arriving at an emergency department across the province annually.[2] Determining where the rehabilitation needs of these patients can be best managed presents a significant challenge to Ontario's health care system. In general, post-stroke rehabilitation in Ontario is provided in three settings: in hospital as an inpatient, in hospital as an outpatient, or in the community (usually in the patient's residence). The key distinction between these services is that in the latter two, the patient lives in the community while accessing care.

In 2010, an Ontario Stroke Evaluation Report noted that the proportion of mild stroke patients being admitted to inpatient rehabilitation was increasing, and suggested that this indicator be considered when monitoring rehabilitation service availability in the community.[2] The report also noted wide variation in inpatient rehabilitation admission practices by region and suggested that this may be partly the result of discrepancies in resource availability. This suggestion is especially troubling given evidence that for moderate-to-mildly impaired patients, post-stroke rehabilitation at home (commonly referred to as Early Supported Discharge, ESD) can improve recovery of functional independence at less cost compared to rehabilitation of similar patients in hospital.[3, 4]

In Canada, the most commonly used measure of function after stroke is the Functional Independence Measure (FIM®). The FIM® provides a valid and reliable indication of caregiver burden and a FIM® score of 100 has been identified as a clinically meaningful cut-point for discharge home from inpatient rehabilitation after stroke.[5] In the United States, studies have reported that patients are discharged from inpatient rehabilitation with a mean FIM® score of 84.8[6] and in Singapore the mean has been reported as 87.3.[7] However, one challenge in using the total FIM® tool for discharge planning is that it does not reflect the patient's cognitive function. Patients can achieve a high total FIM® score in spite of significant cognitive impairment that may affect their ability to return home safely.

In 2006, the Ontario Joint Policy and Planning Committee commissioned the establishment of the Rehabilitation Patient Group (RPG) case-mix classification system in Ontario.[8] The RPG system uses FIM® sub-scores and age to stratify rehabilitation patients on admission to inpatient rehabilitation in terms of their anticipated length of stay in rehabilitation. Of the seven proposed RPG categories for stroke, the group predicted to require the shortest length of stay is referred to as RPG 1160. By definition, patients admitted to inpatient rehabilitation in RPG 1160 have an admission FIM® >100 and a cognitive FIM® score of 30-35 (indicating mild or no cognitive impairment).[8] In 2012 the Ontario Stroke Reference Group (a group of stroke experts from across the province) endorsed a recommendation that, for the purpose of system evaluation, patients in RPG 1160 are suitable candidates for ESD and should not be admitted to inpatient rehabilitation.[9] In 2013, Health Quality Ontario also endorsed this recommendation in their Clinical Handbook for Stroke.[10] In both instances each group explicitly stated that patients in RPG 1160 are likely being admitted to rehabilitation because of a lack of community services, and cautioned that avoiding these unnecessary admissions may not be possible until more community-based rehabilitation resources are available.[9, 10]

The objective of this ecological study was to test the hypothesized association between the proportion of "potentially avoidable" mild admissions to inpatient rehabilitation (RPG 1160) and the availability of in-home rehabilitation in Ontario. It was hypothesized, *a priori*, that unnecessary admission of mild stroke patients to inpatient rehabilitation varies significantly across regions of Ontario. It was further hypothesized, *a priori*, that a significant proportion of this variation could be explained by variation in the availability of post-stroke, in-home rehabilitation to residents of these regions.

5.2 Methods

In 2004, work was begun to divide Ontario into 14 Local Health Integration Networks (LHINs) and in April 2007, these LHINs assumed responsibility of local planning, coordination, and funding of healthcare services.[11] LHIN regions represent geographically distinct divisions of the province that offer an opportunity to assess region-level variation in service availability and discharge patterns. Variation between LHIN regions in the proportion of RPG 1160 patients admitted to inpatient rehabilitation was primary variable of interest in this study.

Research methods met all requirements of the Health Sciences Research Ethics Board at Western University London, Ontario (Appendix D). All data used in this study were compiled by the Institute for Clinical Evaluative Sciences (ICES) in Toronto, Ontario in accordance with their ethics protocols and privacy standards. The majority of data used here are publicly available[12] with the lone exception of data used to calculate the proportion of "potentially avoidable" admissions by LHIN region. Potentially avoidable admissions were calculated by an analyst at ICES using data from the National Rehabilitation Reporting System (NRS). The NRS contains information on patients admitted to registered inpatient rehabilitation beds across Canada and reporting is mandatory in Ontario. NRS records include demographic, clinical and procedural information such as age, sex, birth date, FIM® score, and discharge destination.[13] Patients with primary diagnosis of stroke admitted to inpatient rehabilitation in fiscal years 2006/07 to 2010/11 were identified and retrospectively assigned to an RPG group. Patients in RPG 1160 were labeled as potentially avoidable admissions and the proportion of potentially avoidable admissions, relative to all admissions, was calculated for each LHIN region in each year. This was the dependent variable in all analyses.

Explanatory variable data were compiled from publicly available ICES reports[12] and used to derive 5 indicators of regional in-home rehabilitation resource availability. In Ontario, the majority of government-funded in-home rehabilitation is provided by Community Care Access Clinics (CCACs), which were the focus of these analyses. Indicators of CCAC rehabilitation availability were designed to represent 2 constructs: access and provision. Access indicators were generated to reflect 1) the proportion of stroke survivors in each region who received rehabilitation services from CCAC and 2) the mean number of days between acute discharge and first CCAC visit (wait time). Provision indicators were designed to capture the mean number of services provided to each patient admitted to CCAC after stroke. Provision indicators included the mean number of visits per client for each of physiotherapy (PT), occupational therapy (OT), and speech language pathology (SLP).

Variation in the proportion of potentially avoidable admissions across LHIN regions in each of the five years was assessed using a χ^2 test. Variation in each of the resource indicators across the 5 years was tested using a Kruskal Wallis test. Correlations between the proportion of potentially avoidable admissions and each of the five indicators of resource availability were estimated for each year separately using Spearman's rho. It was hypothesized that four of the five resource indicators (all except wait times) would be negatively correlated with potentially avoidable admissions (ie. fewer CCAC clients, fewer therapy visits per client, and longer wait times would each be associated with more avoidable admissions). Significance in the number of tests whose direction of correlation agreed with the hypothesized direction of effect was tested using a Sign Test.

For each of the five variables, data from all five years were entered into a logistic-linear model. The proportion of potentially avoidable admissions was the dependent variable and year, indicator and the interaction term (year x indicator) were the independent variables. The interaction term was removed if not found to be statistically significant, but year was left in all final models. All analyses were performed using SPSS version 21.0.

5.3 Results

In each fiscal year between 2006 and 2010, 7% of patients admitted to inpatient rehabilitation in Ontario were retrospectively identified as potentially avoidable admissions (RPG 1160, Table 5.1). The proportion of potentially avoidable admissions per LHIN region in a given year ranged from a low of 1.6% in North Simcoe Muskoka (LHIN 12) in 2007 to a high of 17.9% in the North West (LHIN 14) in 2007. LHIN-level comparison of the proportion of potentially avoidable admissions demonstrated significant variation for every year. Variation in four of the five resource indicators were also noted across the five-year period (all $p<0.001$, Table 5.2) with the exception of CCAC rehabilitation clients per acute discharge. The mean number of visits per client by all 3 therapy disciplines (PT, OT, and SLP) generally increased over time, while days from acute discharge to CCAC service decreased in the last 3 years compared to the first 2 years.

Table 5.31- The proportion of "potentially avoidable" admissions (RPG 1160) to inpatient rehabilitation across Ontario's LHINs between 2006/07 and 2010/11.

LHIN	2006/07 RPG 1160/ Total	2006/07 %	2007/08 RPG 1160/ Total	2007/08 %	2008/09 RPG 1160/ Total	2008/09 %	2009/10 RPG 1160/ Total	2009/10 %	2010/11 RPG 1160/ Total	2010/11 %
1	18/257	7.0	14/262	5.3	13/303	4.3	21/308	6.8	25/279	9.0
2	25/351	7.1	41/384	10.7	20/337	5.9	29/363	8.0	24/354	6.8
3	9/154	5.8	18/165	10.9	7/156	4.5	8/172	4.7	11/168	6.5
4	20/454	4.4	22/442	5.0	20/469	4.3	15/451	3.3	24/442	5.4
5	3/70	4.3	2/82	2.4	5/76	6.6	7/101	6.9	5/99	5.1
6	9/237	3.8	8/274	2.9	13/326	4.0	10/310	3.2	7/204	3.4
7	32/535	6.0	24/487	4.9	39/601	6.5	58/603	9.6	35/546	6.4
8	23/256	9.0	20/265	7.5	23/248	9.3	9/268	3.4	16/250	6.4
9	30/366	8.2	22/321	6.9	31/343	9.0	16/320	5.0	16/321	5.0
10	16/127	12.6	13/145	9.0	14/155	9.0	7/149	4.7	8/139	5.8
11	44/350	12.6	58/334	17.4	40/336	11.9	39/341	11.4	39/401	9.7
12	3/101	3.0	2/128	1.6	3/129	2.3	10/146	6.8	4/131	3.1
13	12/202	5.9	9/152	5.9	10/153	6.5	15/207	7.2	20/206	9.7
14	5/79	6.3	17/95	17.9	7/105	6.7	11/121	9.1	12/108	11.1
p-value*	<0.001		<0.001		<0.001		<0.001		0.001	

*p-values derived from Pearson Chi Squared test

Table 5.32 - Summary data on in-home rehabilitation indicators across Ontario's LHINs between 2006/07 and 2010/11.

Resource Indicator	2006/07 Median (Range)	2007/08 Median (Range)	2008/09 Median (Range)	2009/10 Median (Range)	2010/11 Median (Range)	p-value*
Access Indicators						
CCAC Rehab Clients/ 100 Acute Discharges	27 (15-42)	27 (16-43)	27 (16-43)	28 (10-46)	29 (12-50)	.983
Mean Days to Service	33 (28-45)	33 (26-43)	21 (18-26)	19 (17-25)	20 (17-26)	<.001
Provision Indicators						
Mean PT Visits/ Client	3.5 (3.1-5.4)	3.5 (2.8-4.9)	3.3 (2.9-4.3)	3.5 (2.8-4.1)	4.5 (3.6-6.3)	<.001
Mean OT Visits/ Client	2.6 (2.0-3.8)	2.4 (1.9-3.2)	2.4 (1.8-3.1)	3.1 (2.4-5.5)	3.2 (2.0-5.7)	<.001
Mean SLP Visits/ Client	3.1 (2.0-3.9)	2.9 (1.9-3.6)	2.7 (1.6-3.5)	4.1 (2.6-5.9)	4.0 (2.6-6.3)	<.001

*p-values derived from Kruskal Wallis Test.

Spearman's correlation coefficients between the proportion of potentially avoidable admissions to inpatient rehabilitation and each of the resource indicators are presented in Table 5.3. Overall, 21 of the 25 correlations tested (84%) demonstrated an association that agreed with the hypothesized direction of effect (p=0.001). Wait times (days to service) demonstrated the weakest association with potentially avoidable admissions, with 2 of the five correlations in the opposite direction of what was hypothesized. Provision indicators generally demonstrated stronger correlation with potentially avoidable admissions than access indicators. Statistically significant correlations were noted for mean SLP visits per client three times and PT visits per client once.

Table 5.33 - Spearman's Rho (R) correlations between resource indicators and the proportion of potentially avoidable admissions to inpatient rehabilitation (RPG 1160) across Ontario LHIN regions for fiscal years 2006-2010

Resource Indicator	2006/07		2007/08		2008/09		2009/10		2010/11	
	R	p	R	p	R	p	R	p	R	p
Access Indicators										
CCAC Rehab Clients/ Acute Discharge	-.23	.43	-.08	.79	.05	.86	-.50	.07	-.28	.33
Mean Days to Service	.29	.31	-.07	.82	.32	.26	-.03	.92	.00	.99
Provision Indicators										
Mean PT Visits/ Client	-.30	.30	-.20	.49	-.41	.14	-.28	.33	-.56*	.04
Mean OT Visits/ Client	-.23	.43	-.35	.22	.02	.95	-.51	.06	-.32	.27
Mean SLP Visits/ Client	-.54*	<.05	-.59*	.03	-.64*	.01	-.37	.19	-.05	.88

*Significant at p<0.05

Logistic regressions of the frequency of potentially avoidable admissions to inpatient rehabilitation on resource availability by LHIN region were performed for each variable separately. The interaction term (year x indicator) was statistically significant in the models of OT and SLP visits per client. It was removed from the three other models. All slopes agreed with the hypothesized direction of effect and statistically significant correlations at p<0.05 were noted for each variable (Table 5.4).

Table 5.34 - Regressions of the frequency of potentially avoidable admission to inpatient rehabilitation on LHIN-region resource variables for fiscal years 2006-2010 combined, adjusting for year.

Resource Indicator (All models adjusted for year)	Statistical Tests	
	Wald Chi-Squared	p-value
Access Indicators		
CCAC Rehab Clients/Acute Discharge	27.9	<0.001
Mean Days to Service	25.4	<0.001
Provision Indicators		
PT Visits/ Client†	38.3	<0.001
OT Visits/ Client	8.1	0.004
SLP Visits/ Client†	61.8	<0.001

† Adjusted for interaction term (year x indicator)

5.4 Discussion

In Ontario, it has been suggested that a lack of community-based rehabilitation services may contribute to patients being admitted to inpatient rehabilitation unnecessarily after stroke.[2] This ecological study was designed to formally test this hypothesis. In order to do so, RPG group 1160 was used to approximate the proportion of "potentially avoidable" admissions to inpatient rehabilitation across Ontario's LHIN regions and five LHIN-level in-home rehabilitation resource indicators were computed. Correlations between these resource indicators and the proportion of potentially avoidable admissions agreed with the hypothesized direction of effect in 21 out of 25 tests (84%, p=0.001). Furthermore, estimates from logistic regressions for five-years of data were statistically significant for all resource indicator variables. In combination, these results support the hypothesis that at the LHIN level, a lack of in-home rehabilitation resources is associated with higher rates of admission of milder patients to inpatient rehabilitation.

Concern over mild strokes in rehabilitation and insufficient community-based rehabilitation has frequently been expressed in Ontario. In a 2009 survey of Ontario's inpatient rehabilitation facilities, nearly all noted concerns with the availability of community-based rehabilitation and mentioned that this affected their ability to transfer patients to the community in a timely manner.[9] In 2010, Ontario's Stroke Evaluation Report noted an increase in the proportion of mild stroke patients being admitted to inpatient rehabilitation annually and recommended this be measured as an indicator when evaluating resource availability.[2] Despite this recommendation, the correlation between the availability of community rehabilitation resources and admission practices for inpatient rehabilitation has not been formally evaluated previously.

Admitting mildly impaired stroke patients to inpatient rehabilitation unnecessarily is concerning on several fronts. At the patient level, evidence suggests that moderately to mildly impaired patients achieve better outcomes at home[14] and they prefer to receive care in this setting.[15] At the system level, it has been demonstrated that rehabilitation at home can be provided at lower cost to the healthcare system than in-hospital[16] and that reducing admissions of high-functioning patients to inpatient rehabilitation beds may make it easier for more-severely impaired patients to access these limited services.[17]

International research suggests that, for appropriate patients, community-based rehabilitation is an effective method of meeting the rehabilitation needs of high-functioning patients. A meta-analysis performed by Cochrane's Early Supported Discharge Trialists noted that patients participating in ESD programs after stroke demonstrated decreased odds of death or institutionalization, and were more likely to be living at home, independent in daily activities, and satisfied with their outpatient care than were similar controls.[3] In the only published Canadian study of ESD, high-functioning patients admitted to a 4-week home rehabilitation program demonstrated significantly greater improvements in physical function (Stroke Impact Scale), health related quality of life (SF-36) and independent activities of daily living (Older Americans Resource Scale for IADL) compared to patients receiving usual care (including inpatient rehabilitation).[18]

A 2006 health technology assessment concluded that ESD was a "dominant health intervention" in that it resulted in improved patient outcomes at lower cost compared to usual stroke unit care.[4] Similarly, in a follow-up economic analysis to the only Canadian study of ESD, the home-based rehabilitation program was demonstrated to cost an average of $3281 less per patient in the first three months after stroke compared to usual care.[16] Not surprisingly, the cost reductions in these two reports came largely from a reduction in hospital length of stay that was evident in both the acute and rehabilitation settings.

In addition to the direct benefits for high-functioning patients and the potential for cost savings, appropriately resourced community-based rehabilitation also holds tremendous potential for improving system-wide efficiency. A 2012 study in Southwestern Ontario identified 37% of patients being discharged from acute care hospitals as candidates for inpatient rehabilitation; yet only 75% of these were actually admitted.[17] The most frequently cited reason for candidates not being admitted to inpatient rehabilitation was the lack of an available bed. In 2010/11, 246 patients in RPG 1160 were admitted to inpatient rehabilitation across Ontario occupying 3715 rehabilitation bed days (10 bed equivalents).[12] If any or all of these admissions were avoided, the opportunity to improve rehabilitation access for more severely impaired patients could be substantial.

The resource indicators used in this study were designed to reflect 2 distinct, but equally important domains of care: access and provision. As hypothesized, both demonstrated associations with the proportion of potentially avoidable admissions. When faced with a decision regarding discharge destination, it seems reasonable that the more readily available in-home rehabilitation is, the more likely a clinician will be to make a referral to that service. In all analyses, a consistent relationship between the number of patients admitted to CCAC for rehabilitation and the frequency of avoidable admissions was demonstrated. However, mixed results were noted for wait times. One possible explanation is that wait times for CCAC are long in all regions. Although mean wait times were seen to drop between 2006 and 2010, the lowest regional wait time achieved was still 17 days. While wait times might be an important factor when considering discharge to CCAC, they may be of equal concern in all regions, limiting our ability to detect significant associations.

Compared to the access indicators, the provision indicators generally demonstrated stronger correlations with avoidable admissions and all were found to be statistically significant on regression. This may indicate that when clinicians are faced with a decision about discharge destination, they are more interested in the content of the programs than access to them. This effect was most pronounced in the SLP visits per patient indicator where annual correlations were statistically significant in 3 of the 5 years. Estimates suggest that at discharge from an acute hospital, up to 65% of stroke patients demonstrate functional cognitive impairments[19] and 35% symptoms of aphasia.[20] In an Ontario-based study of high-functioning stroke patients, FIM® motor and cognitive sub-scales, Mini Mental State Examination scores, and five items assessing orientation, financial independence, and verbal, written and auditory communication were all significant predictors of long length of stay in inpatient rehabilitation among patients admitted with a FIM® greater than 100.[21] Interventions to address many of these items fall within the scope of practice of SLP and would be the kind of difficulties they would manage in a community setting. If clinicians are concerned with the availability of therapy services in CCAC, they may be more inclined to keep patients in inpatient rehabilitation where they can be sure to get the care they need. Collectively, these provision indicators likely point to areas where targeted investments could have a meaningful impact.

Amid growing concern about limited in-home rehabilitation services, several LHINs have initiated programs to address this issue. In 2009, the South East LHIN implemented an enhanced CCAC program that allowed for greater provision of community rehabilitation to stroke patients.[22] Interestingly, the proportion of potentially avoidable admissions to inpatient rehabilitation in this LHIN went from being above the provincial average between 2006 and 2008, to below average for 2009 and 2010. Similarly, the South West LHIN established community stroke rehabilitation teams in January of 2009, and were below the provincial average for potentially avoidable admissions in fiscal year 2010.

While anecdotal at this point, each of these projects demonstrate the potential impacts of targeted investment and allow the opportunity for more detailed exploration going forward.

This ecological study supports the previously hypothesized association between in-home rehabilitation resources and potentially avoidable admissions to post-stroke inpatient rehabilitation in Ontario. Confirmation of these findings over an extended period of observation would be helpful, but the implications are important. Understanding the impact of in-home rehabilitation programs on referral patterns can help inform future investment decisions and might result in improved patient outcomes, decreased system-wide costs, and improved access to rehabilitation services across the continuum. This information could go a long way in helping to ensure that in the future, patients who experience a stroke in Ontario get the right care in the right place at the right time.

5.5 Limitations

There are a number of limitations in this study that merit consideration. One such limitation is the small number of LHINs in Ontario, which represents a challenge with statistical power and raises concern about type II error. Combining five years of data into one analysis, as was done in the logistic regressions, is one way to overcome this limitation; however, it is not perfect and assumes that each year in each LHIN is statistically independent. Even though there was an adjustment for year in each model (and for an interaction when significant) results must be interpreted with caution.

The resource indicators used in this study were designed to infer regional investment in in-home rehabilitation and were designed to help inform future investment. While the number of visits, admissions and wait times are assumed to approximate the dollars spent on these services, this may not always be the case. These indicators do not explicitly reflect variations in the cost of services or the efficiency with which services are provided in each region. They also do not address geographic challenges faced by the various LHINs which may account for some of the variation in service provision. While the results of this study suggest that investment in in-home rehabilitation will have a beneficial effect, each region should explore their local context and tailor this investment to their specific circumstances.

Similarly, the definition of avoidable admissions operationalized in this study was felt to be the best available, but it should not be interpreted as ideal. Despite general consensus in Ontario's Stroke Reference Group on the use of RPG 1160 as a proxy, it is not possible to confirm that all patients admitted to inpatient rehabilitation in RPG 1160 could have been cared for at home. The RPG groups only reflect functional independence and age. Additional considerations such as the patient's living situation, family support, and safety issues are also frequently factored into the decision about where patients should receive rehabilitation. For instance, very mild communication difficulties aren't necessarily identified by the FIM®, but can be extremely problematic for patients who live alone and aren't able to use a telephone effectively.[23] Conversely, there was also agreement among stroke reference group members that some patients in RPGs 1150 and possibly 1140 might also be able to receive services at home; although there is currently no way of identifying such patients retrospectively. Ongoing research into the clinical characteristics that best predict suitability for community-based rehabilitation is warranted and collection of this data at the system level in Ontario will help to better inform future system-level evaluations.

Finally, this study focused exclusively on in-home rehabilitation resources and neglected the availability of outpatient rehabilitation services. Currently, there is no central database for outpatient rehabilitation in Ontario. At point of discharge from an acute hospital, patients returning to the community are often referred for outpatient rehabilitation as an alternative to in-home CCAC services. It is possible that some of the LHINs with fewer in-home resources have invested in outpatient services instead.

However, one would anticipate the same relationship between outpatient rehabilitation and potentially avoidable admissions as that demonstrated here for in-home rehabilitation. Better data collection on outpatient rehabilitation is paramount and future studies should aim to evaluate the impact of outpatient and CCAC rehabilitation resources in combination.

5.6 Conclusion

In Ontario, the proportion of mild stroke patients admitted to inpatient rehabilitation unnecessarily varies between LHIN regions. Previous work has suggested that one cause of this variation may be a lack of available community-based rehabilitation resources, which is supported by this ecological study. Across LHIN regions, correlations between indicators of in-home rehabilitation availability and potentially avoidable mild admissions were consistently found between fiscal years 2006 and 2010. Furthermore, regression of combined data demonstrated statistically significant associations for all indicators of in-home rehabilitation access and provision. Future research is required to better understand this relationship, to test for similar associations with outpatient rehabilitation resources, and to adjust for differences in patient characteristics between regions.

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Chapter 6 – Discussion and Conclusions

6.1 Summary

This thesis was motivated by concerns that non-trivial numbers of patients who experience a stroke in Ontario are not getting the rehabilitation they need, while others may be getting rehabilitation that is inappropriate for their needs. However, the objective was to go beyond a simple demonstration of inequity and to offer new ways of thinking about stroke system evaluation and novel tools to support future system planning.

Using the literature identified in Chapters 2 and 3, refined criteria were proposed for identifying candidates for both inpatient and in-home rehabilitation. In addition to being useful to clinicians making decisions about referral to post-stroke rehabilitation, these criteria may also be useful to policy makers and health service providers developing regional plans for stroke rehabilitation systems. To demonstrate this potential, the subsequent chapters (4 & 5) built on these refined criteria to assess the equity of access to inpatient rehabilitation across Ontario, and to propose novel ways of testing the relationship between rehabilitation resource availability and discharges to inpatient rehabilitation after stroke. As hypothesized, the results demonstrated significant challenges faced by Ontario's stroke rehabilitation system.

One particular challenge in planning and evaluating rehabilitation systems is identification of the need for services within a given population. Unlike many acute conditions, rehabilitation need is difficult to measure objectively and is often seen as non-urgent. Therefore, historical utilization rates do not necessarily correspond with rehabilitation need. Research in this area has typically focused on professionally defined need by assessing the factors most frequently used by clinicians during patient discharge, which are usually studied through direct survey or indirect observation.[1] While this provides important insight into clinical judgment, studies of these factors generally fail to account for biases in patient selection or the context in which decisions are being made. Clinicians making decisions about referral to rehabilitation may rely on traditional selection criteria that have little to no bearing on outcomes. This was demonstrated in Chapter 2 by the large number of variables that have been frequently explored in multi-variable models without proving to be significant predictors of functional outcome. Furthermore, studies of clinical judgment in environments where inpatient rehabilitation is in short supply may see clinicians refer more severely impaired patients to nursing homes (or long-term care) out of necessity, not because it is best for the patient.[2] To overcome these limitations, Chapter 2 attempted to identify scientifically-confirmed need for post-stroke rehabilitation by focusing on variables that have been demonstrated to show an independent association with post-rehabilitation functional independence, one of the primary objectives of post-stroke rehabilitation.

Years of research into predictors of functional outcomes after post-stroke rehabilitation have led to a substantial amount of literature on the topic. Despite the restrictive inclusion criteria used in Chapter 2, a total of 27 studies reporting 63 multilevel models were identified and, in these models, only a few variables were found to frequently predict functional outcomes. Broadly speaking, the most influential variables fell within the following five general categories: age, initial stroke severity, functional level on acute discharge, cognitive function on acute discharge and history of previous stroke. Each of these constructs can be measured in different ways and more research is required to zero in on the most appropriate measures. Still, the results of Chapter 2 should be helpful in refining future work and suggest that any decision-making algorithm (whether for clinical use or system evaluation) should include at least one variable from each of the five identified categories.

Unfortunately, less research has been devoted to the identification of variables that predict functional outcomes after in-home rehabilitation. While one strength of the methods used in Chapter 3 was the focus on team-coordinated and delivered ESD programs (which have been shown to be the optimal model for ESD delivery[3]) the available literature dictated a focus on variables used in selection for ESD rather than those associated with improved outcomes. Although these studies used a large number of diverse selection criteria, some interesting similarities were identified that should be useful to clinicians and policy makers looking to identify ESD candidates in the future. Not surprisingly, programs generally sought patients with mild-to-moderate functional deficits and potential to improve. However, many studies also noted cognitive deficits as an important consideration, for reasons of both safety and potential to participate in rehabilitation. Furthermore, numerous studies cited pragmatic concerns such as proximity to the hospital and the suitability of the home environment when considering appropriateness for ESD. These findings have considerable policy relevance for large jurisdictions like Ontario and highlight the need for systems of care that account for regional context.

With a better understanding of predictors of functional independence from Chapter 2, Chapter 4 turned to an evaluation of patterns of discharge to inpatient rehabilitation after stroke across Ontario's LHIN regions. In this chapter, the feasibility of using multi-level modelling for system evaluation was demonstrated and discrepancies in regional access to rehabilitation across Ontario were identified. The adjusted estimates of the proportion of patients discharged to inpatient rehabilitation from multi-level analysis provide an improved method for system evaluation compared to the ecologic data typically used. This is important because region-level demographics and risk factor prevalence can contribute not only to variations in stroke incidence, but also to variation in the type of stroke experienced and the corresponding need for rehabilitation. Factors like older age and female sex are associated with increased stroke severity,[4] which means that regions with older populations and more females can anticipate not only more strokes, but more severe strokes requiring more intensive rehabilitation. These factors can have a considerable impact on the regional demand for rehabilitation resources, which must be accounted for both in system planning and evaluation. As innovations like electronic medical records make patient data easier to collect, health service evaluations should use multi-level models more frequently and policy decisions should increasingly be based on their results.

In addition to demonstrating the feasibility of multi-level modelling in Ontario, the results presented in Chapter 4 also supported previous assertions that access to inpatient rehabilitation across Ontario is inequitable. In both cohorts (2004/05 and 2008/09), statistically significant variation in the proportion of patients referred to inpatient rehabilitation was demonstrated across LHIN regions, after adjusting for variation in patient-level characteristics. However, modeled data demonstrated mixed results for the relationship between resource availability and referral patterns. Although the estimates of effect in both cohorts suggested a relationship between more beds and better access, this relationship was statistically significant only in 2004/05, prior to LHIN formation. In combination, these results confirm the need for strategies to improve the equity of rehabilitation access across the province and provide sufficient evidence to warrant pilot study of the role that additional rehabilitation beds may play in addressing inequity. They also suggest opportunities for future research to validate these findings using other data sources and in other jurisdictions.

Finally, Chapter 5 confirmed the suspected association between the availability of in-home rehabilitation resources by LHIN region and the proportion of potentially avoidable admissions of mild stroke patients to inpatient rehabilitation. This result may have the most significant policy-level implications of all. International research has consistently demonstrated that rehabilitation of appropriate patients in the community, rather than in hospital, leads to improved outcomes at reduced cost.[3] In addition, caring for appropriate patients in the community can improve access to much needed inpatient rehabilitation beds (which in turn frees up acute care beds), thereby increasing the capacity of emergency departments. Appropriate funding for community-based rehabilitation can play a major role in ensuring that patients have timely access to a level of rehabilitation appropriate to their needs. This could impact Ontario’s healthcare system in many areas beyond stroke care.

6.2 The Continued Evolution of Ontario's Stroke System

Since the development of the Ontario Stroke System (OSS) in 2000, Ontario's stroke care landscape has changed dramatically and it continues to evolve at an accelerated pace. The OSS was specifically designed to improve stroke care by increasing provincial awareness about the importance of evidence-based care.[5] In 2008, the Ontario Stroke Network (OSN) was developed, in collaboration with the Ministry of Health and Long-Term Care, to provide provincial leadership in furthering the work of the OSS.[6] The OSN was mandated to oversee research and evaluation of Ontario's stroke system and provide guidance and insight into stroke-related planning initiatives. Since 2008 (and after this dissertation was originally proposed), the OSS has benefitted from a number of OSN-funded research initiatives that have continued to advance our understanding of stroke provision across the province.

In 2011 and 2012, the OSN supported three separate but related reports demonstrating significant gaps between current care and best practices in stroke rehabilitation across the province. The first of these reports was a provincial survey of rehabilitation resources released in 2011.[7] In this report, telephone surveys of all rehabilitation hospitals and Community Care Access Centres across the province were undertaken to capture a snapshot of Ontario's capacity for inpatient, outpatient and in-home rehabilitation post stroke. The survey was designed to address gaps in data availability, but ultimately raised more questions than it answered. Survey respondents (primarily program administrators or senior clinical staff) frequently noted that the majority of post-stroke inpatient rehabilitation took place in general rehabilitation beds and often on several units within the same hospital. As a result, it was nearly impossible to retrospectively identify the number of beds or staff available for stroke rehabilitation. Results from outpatient rehabilitation facilities were even more troubling. Very few outpatient rehabilitation facilities collected (or had access to) patient data that could allow them to identify the number of patients with stroke cared for, the number of visits, and/or the reason for these visits. As a result, the data were insufficient for detailed statistical analyses to be performed across regions.

In the same year, the OSN also released its first set of stroke report cards based on 2009/10 Canadian Institute for Health Information (CIHI) data.[8] These reports provided Local Health Integration Networks (LHINs) and healthcare providers across the province with information on their relative performance using 17 indicators of stroke best-practice care ranging from public awareness through to community reintegration. Three additional indicators were also proposed for future reporting, including two related to inpatient rehabilitation (therapy staff to bed ratio and percentage of total length of stay that was alternate level care). Data presented in the reports included provincial averages for each indicator, variance across LHINs, and provincial benchmarks based on the Achievable Benchmarks of Care.[9] On nearly all indicators, the report cards demonstrated dramatic variation across providers and LHINs.[8] These reports became an important platform for arguing the need for changes to stroke care across Ontario.

Despite the data limitations highlighted by the 2011 survey, the information was sufficient to allow for crude province-level analyses to be performed in a subsequent OSN-funded report on the impact of moving to stroke best practices in Ontario.[10] Combined with utilization data from several CIHI databases, survey results were used to develop a provincial model of Ontario’s stroke system, which further identified opportunities for improved application of best-practice recommendations for stroke care. With a focus on earlier admission of patients to inpatient rehabilitation, greater intensity of therapy in inpatient rehabilitation, and investment in outpatient or community-based rehabilitation, the report suggested that as much as $20M could be made available annually for re-investment in Ontario’s stroke system. This report also included a recommendation that patients in Rehabilitation Patient Group 1160 be directly discharged to community-based rehabilitation, which was informed by the methods presented in Chapter 5.

Largely in response to the work performed by the OSS, the OSN, and other provincial initiatives, Ontario's Ministry of Health and Long-Term Care has identified stroke as a key area of focus in several provincial projects including: the Health System Funding Reform, Quality-Based Procedures, and the Rehabilitative Care Alliance. Collectively, these initiatives have brought stroke research to the forefront of policy development in the province and provided a catalyst for ongoing system-level stroke research.

In June 2010, Ontario's government introduced the Excellent Care for All Act with the objective of placing greater emphasis on evidence-informed, patient-centered care.[11] As a component of this process, the government established Health Quality Ontario, with a mandate to advise government and health care providers on the best available evidence to support high-quality care, while also monitoring and reporting to the public on the quality of the health care provided in Ontario.[12] In 2012, this was followed by the release of Ontario's Action Plan for Health Care, which contained the original plan for Health System Funding Reform.[13] Ontario's funding reform was designed to shift the way that Ontario's healthcare system is paid for from the traditional global budget model to an activity-based funding model. Under activity-based funding, healthcare dollars follow the patient and hospitals receive funding based on the volume of services they provide and the quality of care with which they do so. Ontario is among the last jurisdictions in the world to adopt activity-based funding.[14]

As part of Ontario's funding reform, the stated objective is to achieve 70% activity-based funding by 2015. Of this, 40% will be via a Health-Based Allocation Method and the remaining 30% will be funded through Quality-Based Procedures.[15] The Quality-Based Procedures were developed for diagnoses where sufficient evidence exists to develop a best-practice bundled payment method for a well-defined care pathway. Hospitals are to receive an adjusted fixed price for each patient admitted, with which they will be accountable for providing quality care. As a result of the large amount of research available, stroke was selected as one of the first non-elective diagnoses to be funded under this new model in Ontario. In 2012, a provincial expert panel was convened to develop the clinical handbook for stroke[16] and in 2013 a second panel was established to extend the handbook recommendations to the community. These handbooks provide all health service providers in the province with detailed descriptions of the best-practice care they are expected to provide to patients, and stress the importance of cross-sector collaboration.

In addition to the OSN survey results noted previously,[7] additional work across the province has identified significant challenges with data availability, especially in the outpatient rehabilitation sector.[8] The impact this will have on system design for all rehabilitative care has become increasingly apparent. In response, the MoHLTC commissioned the Rehabilitative Care Alliance in 2013 to oversee several projects related to rehabilitation in the province.[17] Five working groups were established as part of the Alliance to develop recommendations on rehabilitation definitions, capacity planning and system evaluation, management of frail senior/medically complex patients, outpatient/ambulatory care, and re-classification considerations for rehabilitation and complex continuing care beds. These groups were designed to address specific challenges within Ontario's rehabilitation system and, although not stroke specific, will provide a platform for improved stroke rehabilitation research in the future.

Finally, in recognition of the need for more stroke system evaluation, in 2013 the OSN received funding through the Strategy for Patient-Oriented Research, in collaboration with the Canadian Institute for Health Research, to develop a research program exploring the impact of Quality-Based Procedures.[18] The project was designed to use available information to perform an evaluation of the consequences (intended and unintended) of Quality-Based Procedures on stroke care in Ontario and to propose an ongoing evaluation framework for future use. In partnership with numerous research groups, the OSN evaluation will undertake a mixed methods approach to help understand the impact of Quality-Based Procedures on planning, care delivery and patient outcomes. Early findings will be used to guide improvements in stroke definitions, development of other non-elective Quality-Based Procedures, and ongoing evaluation. The methods proposed in this thesis will be helpful in informing this important research and designing future evaluations.

While these examples are only a sub-set of the large amount of stroke research being performed in Ontario, collectively they demonstrate an important shift in policy-level thinking related to stroke care. Most importantly, as this work has progressed, data in Ontario continue to suggest improvements in patient care and outcomes. Between 2003 and 2011, the proportion of patients cared for in a specialized stroke centre in Ontario increased from 44% to 55% and the proportion of patients discharged to long-term care dropped from 9% to 6%.[19] During the same period, the mean time between stroke onset and rehabilitation admission decreased from 21 days to 16 days - still considerably longer than recommended, but moving in the right direction.[19] In general, nearly all indicators suggest that stroke care is improving across the province. Opportunities for further improvement still exist and it is hoped that the methods offered here will continue to make a positive contribution to these ongoing initiatives.

6.3 Opportunities for Future Research

This thesis was designed to address some of the challenges in the evaluation of Ontario's stroke system and, in doing so, has uncovered several opportunities for future research. In general, these opportunities relate to further refinement of criteria to select patients for various types of post-stroke rehabilitation, additional opportunities to apply the statistical methods proposed here, and expansion of this research to other patient populations.

Despite the wealth of literature uncovered in Chapter 2, additional research is required to refine our understanding of the utility of some key variables in predicting patient outcomes after rehabilitation. This will be helpful both to clinicians making decisions about rehabilitation referrals and to policy makers undertaking health system planning.

When aiming to predict functional outcomes after rehabilitation, Chapter 2 identified five categories of variables that should be adjusted for. Using these categories to properly adjust for confounding, refined models should be developed in a few key areas at minimum. First, a vast amount of research has been performed on the utility of measures of cognitive function for predicting functional outcomes (with mixed results). This may be due to inconsistent methods of measurement of cognitive function and variation in methods for model development. Indicators of cognitive function such as impulsivity, neglect, and dysphasia have shown promise, while others like problem solving have proven less useful. Given the consensus around the importance of cognitive function in rehabilitation selection, more targeted research into this group of measures is necessary. Second, very few process indicators have been explored in properly adjusted models. The most frequently tested (and most frequently significant) variable, onset admission interval, is an important example of the role that process variables can play in patient recovery during rehabilitation. Utilization of properly adjusted multi-variable models can help to identify the importance of other similar variables and to inform targeted intervention strategies.

The focus of Chapter 2 was predictors of functional outcomes, which are the most commonly used measures of outcome in post-stroke rehabilitation.[20] However, additional outcomes may be equally or more important to patients recovering from stroke. The review performed in Chapter 2 could easily be replicated for additional outcomes such as discharge destination, cognitive function, quality of life, or community-reintegration. These additional measures may provide further insight into the full range of benefits of post-stroke rehabilitation and the patients most likely to show improvement.

In contrast with the large number of studies reporting multi-variable models to predict functional outcomes after inpatient rehabilitation, a lack of similar research for outpatient and community-based rehabilitation is evident in Chapter 3. As health information becomes more readily available, emphasis should be placed on developing similar models in these settings while applying what has been learned in the inpatient rehabilitation literature. Some advantages in starting this research now are that emphasis can be placed from the beginning on multivariable models (rather than single variable exploration) and that statistical software packages available now make developing these models relatively easy. As local and regional outpatient and community-based rehabilitation programs enhance their data collection, multi-variable models should be used to explore the predictive utility of admission variables on patient outcomes and these analyses should be considered for inclusion in routine reporting.

As research progresses in all areas of rehabilitation (inpatient, outpatient, and community), emphasis should be placed in all areas on developing well-adjusted predictive models that are sufficiently powered to test for multi-variable interactions and clinically relevant strata in important measures. Clinicians and policy makers are frequently searching for scientifically confirmed indicators of rehabilitation need but, to date, only crude criteria have been proposed. While examples like Health Quality Ontario's recommendation of an alpha Functional Independence Measure (FIM®) score >80,[16] or Holmqvist's exclusion of patients with a Mini Mental State Examination score <23[21] from community-based rehabilitation are helpful, in isolation they fail to reflect the important context in which these decisions are being made; this includes the patient's cognitive status in the first example, and physical status in the second. The Rehabilitation Patient Group methodology for identifying "potentially avoidable" acute admissions in Chapter 5 offered an improvement by accounting for age, motor and cognitive FIM® simultaneously; however, it still fails to account for other factors like living arrangement and caregiver support. No statistical model will ever completely replace clinical decision making, but more complete algorithms that account for a large number of predictive variables may help to better inform the processes of referral to appropriate rehabilitation and system evaluation.

While the previously noted areas of future research regarding patient selection are important, the real aim of this thesis was to propose improved methods for evaluation of Ontario's stroke rehabilitation system. Arguably the most important contribution that this thesis can make is the multi-level modelling technique developed in Chapter 3. Demonstration of the feasibility of using multi-level models for LHIN-level comparisons opens the door for opportunities to use similar techniques in future research of all aspects of stroke rehabilitation. Furthermore, these methods could also prove useful in benchmark development and for comparisons between other clusters of patients.

The most obvious extension of the multi-level modelling techniques presented in Chapter 3 would be evaluation of Ontario's outpatient and community-based rehabilitation sectors. At present, there is insufficient data to develop a multi-level model to assess variation in avoidable admissions to inpatient rehabilitation, which is why Chapter 5 relied on ecological methods. As health information becomes more readily available, multi-level models should be developed to test for regional variation in access to outpatient and community-based rehabilitation services as well as other programs including complex continuing care and long-term care.

While evaluation efforts such as the OSN's report cards have been influential in promoting discussion about the need for policy-level changes across Ontario, questions remain regarding the comparability of the data used. Health system evaluation has almost exclusively relied on regional ranks using unadjusted, crude, population-level statistics.[8] The adjusted estimates of access to rehabilitation presented in Chapter 3 are a good example of the way that, if available, adjusting for patient-level data can improve comparability between regions. Furthermore, the estimates of effect and statistical inferences made possible by these models provide a much better indication of whether things are really different between regions. Adoption of these techniques (and the associated statistical inferences) could allow organizations like the OSN to compare regions on a large number of indicators and to highlight only the ones where they are statistically better or worse than their peers. The potential usefulness of this sort of analysis is two-fold: regions observed to be top performers can be studied to better understand the reasons for their success, and regions with the worst performance are logical starting points for efforts at improvement.

This thesis focused on LHIN regions as the units of analysis, but similar techniques could be used to explore other levels of analysis as well. For example, multi-level modelling techniques are frequently used to compare outcomes among healthcare providers.[22] This was not done in this thesis because hospitals in Ontario do not operate within distinct catchment areas across the province, making regional comparisons at the facility level difficult. However, as stroke services are increasingly consolidated at regional and district stroke centers (as recommended by Health Quality Ontario[16]), these types of analyses may become more appropriate. In addition, similar adjusted analyses could be explored between provinces and territories as information becomes more readily available in all regions of Canada.

Finally, this thesis focused on stroke care largely because of the advanced stage of stroke rehabilitation research and the provincial emphasis on stroke services. However, these methods could easily be applied to other patient populations when assessing regional equity in access to rehabilitation services. Nearly all LHINs have begun, or completed, capacity assessments for rehabilitation services and the work of the Rehabilitative Care Alliance should help to promote similar work in all regions across the province. As this is undertaken, the methods presented here for inferring patient needs and rehabilitation suitability may prove helpful, as may the methods for multi-level comparison between regions when data are available.

6.4 Summary

Effective stroke rehabilitation requires coordination of a wide variety of services beyond inpatient care. This thesis confirmed that, in Ontario, access to inpatient rehabilitation after stroke varies across the province. Furthermore, the findings add support to previous suspicions of an association between the availability of inpatient rehabilitation beds and access to these services while, at the same time, demonstrating correlations between access to community-based rehabilitation and the proportion of mildly impaired patients being admitted to inpatient care unnecessarily. It appears that Ontario's stroke rehabilitation system requires a realignment of services to ensure that all patients have access to the rehabilitation they need in the right setting at the right time. Fortunately, numerous initiatives are under way to address these issues. It is hoped that the methods proposed here will be useful in supporting this work and in informing future system evaluation to help ensure that Ontario's stroke rehabilitation is equitable, accessible and responsive to the needs of everyone who experiences a stroke.

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Appendices

Appendix A: Search criteria for review of multi-level models of functional outcomes after inpatient rehabilitation

MED LINE

1. Patient Discharge/mt, og, st, sn, td [Methods, Organization & Administration, Standards, Statistics & Numerical Data, Trends]

2. exp patient discharge/ or exp patient transfer/ or exp emergency medical services/

3. 1 or 2

4. (emergency medical services or emergency care or discharge disposition or patient discharge or hospital disposition or discharge or patient transfer).mp. [mp=title, original title, abstract, name of substance word, subject heading word, unique identifier]

5. 3 or 4

6. prognosis/ or exp disease-free survival/ or exp medical futility/ or exp nomograms/ or exp treatment outcome/

7. Forecasting/mt [Methods]

8. 6 or 7

9. (predict* or prognos* or Forecast*).mp. [mp=title, original title, abstract, name of substance word, subject heading word, unique identifier]

10. 8 or 9

11. rehabilitation/ or exp "activities of daily living"/ or exp exercise therapy/ or exp occupational therapy/ or exp recreation therapy/ or exp "rehabilitation of speech and language disorders"/

12. (rehabilitat* or occupational therapy .mp. [mp=title, original title, abstract, name of substance word, subject heading word, unique identifier]

13. 11 or 12

14. exp Stroke/

15. (stroke or cerebrovascular accident or cerebral infarct).mp. [mp=title, original title, abstract, name of substance word, subject heading word, unique identifier]

16. 14 or 15
17. 5 and 10 and 13 and 16
18. limit 17 to journal article

EMBASE

1. exp emergency medicine/ or exp emergency care/
2. exp hospitalization/ or exp hospital discharge/ or exp hospital patient/ or exp treatment outcome/
3. exp hospital admission/
4. (emergency medicine or emergency care or hospitalization or hospital discharge or hospital patient or treatment outcome or hospital admission).mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name]
5. exp prognosis/ or exp prediction/
6. forecasting/ or "prediction and forecasting"/
7. communication disorder/ or therapy/ or rehabilitation/ or rehabilitation care/ or rehabilitation medicine/
8. (prognos* or predict* or forecast*).mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name]
9. (rehabilitat* or therapy).mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name]
10. exp stroke/ or stroke patient/
11. (stroke or stroke patient or cerebrovascular accident or cerebral infarct).mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name]
12. 1 or 2 or 3 or 4
13. 5 or 6 or 8
14. 7 or 9
15. 10 or 11
16. 12 and 13 and 14 and 15

17. limit 16 to article or journal

PsycINFO

all((cerebral ischemia OR cerebral hemorrhage OR cerebrovascular accidents) AND (prognosis OR disease course OR prediction OR predictability measurement OR prediction errors OR probability OR statistical analysis OR statistical estimation OR statistical estimation OR statistical measurement) AND (rehabilitation OR treatment OR occupational therapy OR physical therapy OR activities of daily living OR rehabilitation centers) AND (medical patients OR after care OR client characteristics OR clinical judgement OR discharge planning OR disease management OR geriatric patients OR hospitalized patients OR treatment planning))

CINAHL

1.("emergency care") or (MH "Discharge Planning") or (MH "Discharge Planning (Iowa NIC)") or (MH "Transfer, Discharge") or (MH "Patient Discharge") or (MH "After Care") or (MH "Acute Care") or (MH "Emergency Care+")

2.acute care OR after care OR patient discharge OR patient transfer OR discharge planning

3.1 or 2

4.("forecast") or (MH "Prognosis+") or (MH "Forecasting")

5.predict* OR prognos*

6.4 or 5

7.("rehabilitation") or (MH "Rehabilitation+") or (MH "Rehabilitation Centers+") or (MH "Rehabilitation Exercise (Saba CCC)")

8.(MH "Stroke") or (MH "Stroke Patients") or (MH "Stroke Units") or (MH "NIH Stroke Scale") or (MH "Cerebral Ischemia+") or (MH "Cerebral Ischemia, Transient") or (MH "Hypoxia-Ischemia, Brain") or (MH "Intracranial Hemorrhage") or (MH "Cerebral Hemorrhage") or (MH "Basal Ganglia Hemorrhage")

9.stroke OR stroke patients OR stroke units OR NIH stroke scale OR cerebral ischemia OR hypoxi* ischemia OR intracranial hemorrhage OR cerebral hemorrhage OR basal ganglia hemorrhage

10.8 or 9

11.3 and 6 and 7 and 10

Appendix B: Criteria used to supplement Quality in Prognosis Studies (QUIPS) tool when assessing low, moderate, or high potential for bias in identified studies.

Participation

- Low if >80% participation by eligible participants, or no difference between groups and all prompts met
- Mod if 50 – 80% participation and/or not all prompts described
- High if <50% and/or issues with any prompts and/or a study includes only a subset of stroke patients

Note: for this review, "eligible participants" refers to all patients with confirmed diagnosis of stroke (Ischemic at least); NOT the study definition of eligible. Exclusion of transient ischemic attack, sub-arachnoid hemorrhage, or intra-cerebral hemorrhage patients is acceptable if all other criteria above are met.

Attrition

- Low if <10% attrition, or no difference between groups and all prompts met
- Mod if 10-30% attrition and/or not all prompts described
- High if >30% attrition and/or issues with any prompts

Prognostic Factor (PF) Measurement

- Low if all novel PF measurement is described adequately, is consistent and aligns with prompts, and common PFs are valid and reliable and measured for all patients
- Mod if description of novel PF measurement is not mentioned
- High if measurement of any PFs does not agree with prompts

Outcome Measurement

- Low if FIM or BI is measured at discharge by appropriate professionals (by trained personnel if FIM), and is the same for all participants
- Mod if outcome measurement is not adequately described
- High if concern arises as to the methods for outcome measurement

Study Confounding

- Low if confounding variables included a sufficient mix of variables representing demographic/social information, medical/clinical information (including stroke data), and a measure of functional status at baseline
- Mod if confounding variables exclude 1 of the previously mentioned information
- High if confounding variables exclude 2 or more of the previously mentioned information or are not described

Statistical analysis

- Low if all prompts are addressed
- Mod if one or more prompts are not addressed
- High if one or more prompts are not addressed and/or methods are not described

Appendix C: Search strategy for review of early supported discharge trials

MEDLINE

1. Home Care Services, Hospital-Based (SH) OR early supported discharge.mp. OR Home Care Services (SH)
2. Rehabilitation Centers (SH) OR Rehabilitation (SH) OR rehab*.mp.
3. stroke.mp. OR exp Stroke (SH)
4. 1 AND 2 AND 3

EMBASE

1. community care/ OR home care/ OR early supported discharge.mp.
2. rehabilitation center/ OR rehab*.mp. OR rehabilitation/
3. (stroke OR cerebrovascular accident).mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer]
4. 1 AND 2 AND 3

CINAHL

1. (MH "Rehabilitation, Community-Based") OR community-based
2. (MH "Outpatient Service") OR outpatient OR (MH "Outpatients")
3. (MH "Early Patient Discharge/MT/OG/MA/ST/TD/UT") OR early supported discharge
4. 1 OR 2 OR 3
5. (MH "Rehabilitation") OR (MH "Rehabilitation Centers") OR rehab*
6. (MH "Stroke") OR stroke OR (MH "Stroke Patients") OR (MH "Stroke Units")
7. 4 AND 5 AND 6

Appendix D – Letter of assessment from the Health Sciences Research Ethics Board at Western University London, Ontario

This dissertation arose from an OSN-funded research project entitled "An Economic Model for Stroke Rehabilitation in Ontario: Mapping Resource Availability and Patient Needs". The dissertation was expended to meet the requirements of the PhD program and the title was changed; however, the methods for accessing and analyzing data included in the original HSREB submission remained the same.

COPY

Western

Office of Research Ethics
The University of Western Ontario
[redacted]

March 3, 2010

Mr. Matthew Meyer
c/o Dr. Robert Teasell
[redacted]

Dear Dr. Teasell

Re: <u>HSREB Submission #16890E</u>

We are in receipt of your submission to the HSREB; however, the above-referenced project does not require approval of a Research Ethics Board. According to UWO HSREB Guideline 1-G-002 and The Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans, Articles 3.3-3.6, a project in which the secondary use of data is derived from information or a sample for which no direct linkage with an individual study subject is possible would not be subject to REB review.

http://www.uwo.ca/research/ethics/nonboard/1g002-guideline-secondary-data-feb-2002.pdf

In my opinion, your research project entitled: *"An Economic Model for Stroke Rehabilitation in Ontario: Mapping Resource Availability and Patient Needs"* falls within that description.

I wish you the best of luck with your work.

Most sincerely,

[redacted]

Denise Grafton, Ph.D.,
Senior Ethics Officer
[redacted]

Appendix E – Sample of the SAS code used for multi-level analysis testing the relationship between inpatient rehabilitation availability and discharge to inpatient rehabilitation after stroke in Chapter 4.

```
data AdmittedPts;
  set IPneed.IPRehabNeedCohort;
  if OSA='FY0405';
  if FD_StrokeTypeFinal^='Tia';

if SD_LocArrival='Unconscious' then SD_CNSScore=0;

format gr_SD_CNSSCore $12.;
if 0<=SD_CNSScore<=3 then gr_SD_CNSScore='1)0-3';
else if 3< SD_CNSScore<=8 then gr_SD_CNSScore='2)4-8';
else gr_SD_CNSScore ='3)>8';

format gr_D_RankinScore $10.;
if D_RankinScore in (0 1 2) then gr_D_RankinScore='1)0-2';
else if D_RankinScore >=3 then gr_D_RankinScore='2)3-5';
else if D_RankinScore=. then gr_D_RankinScore='3)missing';

D_Rehab_OSA =(D_DischargeTo='Rehab');

if LHIN_pt ='01' then do; LHIN_beddays=14377; LHIN_BedDaysPerstrokePt=17.9; end;
else if LHIN_pt ='02' then do; LHIN_beddays=14497; LHIN_BedDaysPerstrokePt=17.8;
end;
else if LHIN_pt ='03' then do; LHIN_beddays= 5662; LHIN_BedDaysPerstrokePt=10.7;
end;
```

```
else if LHIN_pt ='04' then do; LHIN_beddays=19085; LHIN_BedDaysPerstrokePt=13.9;
end;
else if LHIN_pt ='05' then do; LHIN_beddays=  504; LHIN_BedDaysPerstrokePt= 1.0;
end;
else if LHIN_pt ='06' then do; LHIN_beddays=11074; LHIN_BedDaysPerstrokePt=16.3;
end;
else if LHIN_pt ='07' then do; LHIN_beddays=24578; LHIN_BedDaysPerstrokePt=25;
end;
else if LHIN_pt ='08' then do; LHIN_beddays= 8742; LHIN_BedDaysPerstrokePt= 8;
end;
else if LHIN_pt ='09' then do; LHIN_beddays=14107; LHIN_BedDaysPerstrokePt=11.8;
end;
else if LHIN_pt ='10' then do; LHIN_beddays= 8049; LHIN_BedDaysPerstrokePt=15.8;
end;
else if LHIN_pt ='11' then do; LHIN_beddays=20078; LHIN_BedDaysPerstrokePt=24;
end;
else if LHIN_pt ='12' then do; LHIN_beddays= 4143; LHIN_BedDaysPerstrokePt= 9.3;
end;
else if LHIN_pt ='13' then do; LHIN_beddays= 6274; LHIN_BedDaysPerstrokePt=10.1;
end;
else if LHIN_pt ='14' then do; LHIN_beddays= 2738; LHIN_BedDaysPerstrokePt=10.6;
end;

if SD_LOCArrival^='Alert' then LOCArrival='Other';
else LOCArrival='Alert';

if ER_RegistryArrFrom^='Home' then RegistryArrFrom='Other';
else RegistryArrFrom='Home';
run;
*********************************************************************
```

```
*** Model 1) with addition of all forced-in and explored level-1 variables
******************************************************************************;
%let vars=
DM_Gender
gr_SD_CNSScore
DM_Liveswith
GR_D_RankinScore
PMH_Stroke
FD_StrokeTypefinal
HC_Swallowing
LOCarrival
PMH_Asthma
PMH_Dementia
PMH_Depression
PMH_Preeventstatus
PMH_TIA
PMH_Diabetes
PMH_Hypertension
PMH_Hyperlipidemia
PMH_SmokeHistory
PMH_PulmEdema
PMH_Carotid
PMH_Cancer
PMH_Renal
PMH_Cirrhosis
PMH_PeripheralDisease
PMH_AtrialFib
PMH_CAD
HCP_AtrialFib
HCP_Pneumonia
```

```
HI_NG
HI_Feedingtube
RegistryArrFrom;

title1 'Multilevel Model: 1';
title2 'All forced-in variables';

ods output parameterestimates=para_a tests3=tests3;
proc glimmix data= AdmittedPts;
class LHIN_pt &vars/ref=first;
model D_Rehab_OSA(event='1') =&vars DM_Age/dist=binary link=logit ddfm=bw
solution OR;
random intercept /subject =LHIN_pt solution;
run;
ods output close;

***********************************************************************
*** Model 2)
***********************************************************************;
title1 'Multilevel Model: 2';
title2 'Model 1 with only forced-in and p<0.2 vars';
*** Select p<0.2 vars;
data sigvar;
set tests3;
if ProbF<0.2;
run;
*** Create sigvar macro variable;
proc sql noprint;
select effect into: sigvar separated by " "
from sigvar
```

```
where effect not in ('DM_Age');
quit;
%put &sigvar;

proc glimmix data=AdmittedPts;
class LHIN_pt &sigvar /ref=first;
model D_REhab_OSA(event='1') =&sigvar DM_Age/dist=binary link=logit ddfm=bw
solution OR;
random intercept /subject =LHIN_pt solution;
run;

***********************************************************************
*** Model 3)
***********************************************************************;
title1 'Multilevel Model: 3';
title2 'Model 2 with LHIN_Beddaysperstroke';

proc glimmix data= AdmittedPts;
class LHIN_pt &sigvar/ref=first;
model D_REhab_OSA(event='1') =&sigvar DM_Age LHIN_BedDaysPerStrokePt
    /dist=binary link=logit ddfm=bw solution OR;
random intercept /subject =LHIN_pt solution;
run;
```

Appendix F – Output from multi-level models presented in Chapter 4

The GLIMMIX procedure was used in all models developed in Chapter 4 to test for variation in discharges to inpatient rehabilitation after stroke adjusting for patient characteristics. Three models were developed for each cohort (2004/05 and 2008/09). All corresponding SAS output is presented below. Variable names in each model are those assigned by the Institute for Clinical Evaluative Sciences (ICES). A plain language summary of all patient-level variables is included in Chapter 4.

Cohort – 2004/05 Model #1

Data Set	WORK.ADMITTEDPTS
Response Variable	D_Rehab_OSA
Response Distribution	Binary
Link Function	Logit
Variance Function	Default
Variance Matrix Blocked By	LHIN_pt
Estimation Technique	Residual PL
Degrees of Freedom Method	Between-Within

Class Level Information		
Class	Levels	Values
LHIN_pt	14	02 03 04 05 06 07 08 09 10 11 12 13 14 01
DM_Gender	2	Male Female
gr_SD_CNSSCore	3	2)4-8 3)>8 1)0-3
DM_LivesWith	3	Others UTD Alone
gr_D_RankinScore	3	2)3-5 3)missing 1)0-2
PMH_Stroke	2	Yes No
FD_StrokeTypeFinal	4	Ischemic SAH UTD ICH
HC_Swallowing	2	Yes No
LOCArrival	2	Other Alert
PMH_Asthma	2	Yes No
PMH_Dementia	2	Yes No
PMH_Depression	2	Yes No
PMH_PREEVENTSTATUS	2	Independent Dependent
PMH_TIA	2	Yes No
PMH_Diabetes	2	Yes No
PMH_Hypertension	2	Yes No
PMH_Hyperlipidemia	2	Yes No
PMH_SMOKEHISTORY	3	Former Nonsmoker Current
PMH_PulmEdema	2	Yes No

Class Level Information		
Class	Levels	Values
PMH_Carotid	2	Yes No
PMH_Cancer	2	Yes No
PMH_Renal	2	Yes No
PMH_Cirrhosis	2	Yes No
PMH_PeripheralDisease	2	Yes No
PMH_AtrialFib	2	Yes No
PMH_CAD	2	Yes No
HCP_AtrialFib	2	Yes No
HCP_Pneumonia	2	Yes No
HI_Ng	2	Yes No
HI_FeedingTube	2	Yes No
RegistryArrFrom	2	Other Home

Number of Observations Read	2000
Number of Observations Used	2000

Response Profile		
Ordered Value	D_Rehab_OSA	Total Frequency
1	0	1378
2	1	622
The GLIMMIX procedure is modeling the probability that D_Rehab_OSA='1'.		

Dimensions	
G-side Cov. Parameters	1
Columns in X	68
Columns in Z per Subject	1
Subjects (Blocks in V)	14
Max Obs per Subject	248

Optimization Information	
Optimization Technique	Newton-Raphson with Ridging
Parameters in Optimization	1
Lower Boundaries	1
Upper Boundaries	0
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	Restarts	Subiterations	Objective Function	Change	Max Gradient
0	0	5	9008.98687	1.25790820	0.000014
1	0	3	9679.1958618	0.30026317	0.000175
2	0	2	9902.0002146	0.03055512	6.665E-6
3	0	1	9918.5587597	0.00062228	0.000013
4	0	1	9918.6723949	0.00000549	1.286E-9
5	0	0	9918.6727212	0.00000000	7.748E-7

Convergence criterion (PCONV=1.11022E-8) satisfied.

Fit Statistics	
-2 Res Log Pseudo-Likelihood	9918.67
Generalized Chi-Square	1907.46
Gener. Chi-Square / DF	0.97

Covariance Parameter Estimates					
Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
Intercept	LHIN_pt	0.2943	0.1440	2.04	0.0204

Odds Ratio Estimates						
Variable	Comparator	Referent	DF	OR	95% CI	
DM_Gender	Male	Female	13	0.935	0.714	1.225
gr_SD_CNSSCore	4-8	0-3	25	1.555	0.773	3.128
	>8	0-3	25	1.226	0.592	2.539
DM_LivesWith	Others	Alone	24	0.720	0.542	0.958
	UTD	Alone	24	0.521	0.233	1.163
gr_D_RankinScore	3-5	0-2	19	15.145	10.310	22.246
	missing	0-2	19	4.569	1.365	15.295
PMH_Stroke	Yes	No	13	0.879	0.648	1.193
FD_StrokeTypeFinal	Ischemic	ICH	37	0.926	0.594	1.444
	SAH	ICH	37	1.323	0.408	4.285
	UTD	ICH	37	0.453	0.238	0.863
HC_Swallowing	Yes	No	13	1.708	1.292	2.259
LOCArrival	Other	Alert	13	0.588	0.338	1.023
PMH_Asthma	Yes	No	13	0.624	0.408	0.955
PMH_Dementia	Yes	No	13	0.272	0.156	0.474
PMH_Depression	Yes	No	13	0.584	0.376	0.908
PMH_PREEVENTSTATUS	Independent	Dependent	13	2.055	1.466	2.880
PMH_TIA	Yes	No	13	0.919	0.626	1.349
PMH_Diabetes	Yes	No	13	1.102	0.827	1.470
PMH_Hypertension	Yes	No	13	0.878	0.662	1.164
PMH_Hyperlipidemia	Yes	No	13	1.104	0.822	1.483
PMH_SMOKEHISTORY	Former	Smoker	26	0.919	0.592	1.427
	Non-Smoker	Smoker	26	0.811	0.564	1.167
PMH_PulmEdema	Yes	No	13	1.010	0.615	1.657
PMH_Carotid	Yes	No	11	0.664	0.252	1.746
PMH_Cancer	Yes	No	13	0.754	0.510	1.114
PMH_Renal	Yes	No	8	1.028	0.222	4.761

Odds Ratio Estimates						
Variable	Comparator	Referent	DF	OR	95% CI	
PMH_Cirrhosis	Yes	No	8	0.826	0.198	3.451
PMH_PeripheralDiseas	Yes	No	13	1.039	0.600	1.799
PMH_AtrialFib	Yes	No	13	0.982	0.690	1.397
PMH_CAD	Yes	No	13	0.834	0.620	1.122
HCP_AtrialFib	Yes	No	13	0.976	0.490	1.942
HCP_Pneumonia	Yes	No	12	1.522	0.743	3.117
HI_Ng	Yes	No	13	1.053	0.615	1.803
HI_FeedingTube	Yes	No	12	0.957	0.448	2.044
RegistryArrFrom	Other	Home	13	0.688	0.497	0.952
DM_Age		74.86	1949	0.997	0.987	1.008

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
DM_Gender	1	13	0.29	0.6016
gr_SD_CNSSCore	2	25	2.25	0.1260
DM_LivesWith	2	24	3.46	0.0477
gr_D_RankinScore	2	19	109.77	<.0001
PMH_Stroke	1	13	0.83	0.3791
FD_StrokeTypeFinal	3	37	3.12	0.0374
HC_Swallowing	1	13	17.18	0.0012
LOCArrival	1	13	4.29	0.0588
PMH_Asthma	1	13	5.74	0.0323
PMH_Dementia	1	13	25.63	0.0002
PMH_Depression	1	13	6.95	0.0206
PMH_PREEVENTSTATUS	1	13	21.23	0.0005
PMH_TIA	1	13	0.22	0.6434
PMH_Diabetes	1	13	0.54	0.4766
PMH_Hypertension	1	13	1.00	0.3364

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
PMH_Hyperlipidemia	1	13	0.52	0.4828
PMH_SMOKEHISTORY	2	26	0.81	0.4555
PMH_PulmEdema	1	13	0.00	0.9671
PMH_Carotid	1	11	0.87	0.3713
PMH_Cancer	1	13	2.44	0.1424
PMH_Renal	1	8	0.00	0.9678
PMH_Cirrhosis	1	8	0.10	0.7654
PMH_PeripheralDiseas	1	13	0.02	0.8824
PMH_AtrialFib	1	13	0.01	0.9136
PMH_CAD	1	13	1.74	0.2099
HCP_AtrialFib	1	13	0.01	0.9394
HCP_Pneumonia	1	12	1.63	0.2262
HI_Ng	1	13	0.04	0.8381
HI_FeedingTube	1	12	0.02	0.9024
RegistryArrFrom	1	13	6.18	0.0273
DM_Age	1	1949	0.30	0.5843

Solution for Random Effects								
Effect	Subject	Estimate	Std Err Pred	DF	t Value	Pr > |t|	Lower	Upper
Intercept	LHIN_pt 02	-0.036	0.2241	1962	-0.16	0.871	-0.475	0.403
Intercept	LHIN_pt 03	-0.179	0.2780	1962	-0.64	0.519	-0.724	0.366
Intercept	LHIN_pt 04	-0.002	0.2093	1962	-0.01	0.992	-0.412	0.408
Intercept	LHIN_pt 05	-0.606	0.3099	1962	-1.96	0.050	-1.214	0.001
Intercept	LHIN_pt 06	-0.408	0.2534	1962	-1.61	0.107	-0.905	0.088
Intercept	LHIN_pt 07	0.238	0.2301	1962	1.04	0.300	-0.212	0.689
Intercept	LHIN_pt 08	0.024	0.2275	1962	0.11	0.913	-0.421	0.471
Intercept	LHIN_pt 09	0.189	0.2203	1962	0.86	0.390	-0.243	0.621
Intercept	LHIN_pt 10	-0.200	0.2651	1962	-0.76	0.449	-0.720	0.319
Intercept	LHIN_pt 11	0.687	0.2402	1962	2.86	0.004	0.216	1.158
Intercept	LHIN_pt 12	-0.873	0.2976	1962	-2.93	0.003	-1.457	-0.289
Intercept	LHIN_pt 13	-0.021	0.2420	1962	-0.09	0.928	-0.496	0.452
Intercept	LHIN_pt 14	0.072	0.3312	1962	0.22	0.826	-0.577	0.722
Intercept	LHIN_pt 01	1.116	0.2510	1962	4.45	<.001	0.623	1.608

Cohort 2004/05 Model #2

Data Set	WORK.ADMITTEDPTS
Response Variable	D_Rehab_OSA
Response Distribution	Binary
Link Function	Logit
Variance Function	Default
Variance Matrix Blocked By	LHIN_pt
Estimation Technique	Residual PL
Degrees of Freedom Method	Between-Within

Class Level Information		
Class	Levels	Values
LHIN_pt	14	02 03 04 05 06 07 08 09 10 11 12 13 14 01
gr_SD_CNSSCore	3	2)4-8 3)>8 1)0-3
DM_LivesWith	3	Others UTD Alone
gr_D_RankinScore	3	2)3-5 3)missing 1)0-2
FD_StrokeTypeFinal	4	Ischemic SAH UTD ICH
HC_Swallowing	2	Yes No
LOCArrival	2	Other Alert
PMH_Asthma	2	Yes No
PMH_Dementia	2	Yes No
PMH_Depression	2	Yes No
PMH_PREEVENTSTATUS	2	Independent Dependent
PMH_Cancer	2	Yes No
RegistryArrFrom	2	Other Home

Number of Observations Read	2000
Number of Observations Used	2000

Response Profile		
Ordered Value	D_Rehab_OSA	Total Frequency
1	0	1378
2	1	622

The GLIMMIX procedure is modeling the probability that D_Rehab_OSA='1'.

Dimensions	
G-side Cov. Parameters	1
Columns in X	31
Columns in Z per Subject	1
Subjects (Blocks in V)	14
Max Obs per Subject	248

Optimization Information	
Optimization Technique	Newton-Raphson with Ridging
Parameters in Optimization	1
Lower Boundaries	1
Upper Boundaries	0
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	Restarts	Subiterations	Objective Function	Change	Max Gradient
0	0	5	8988.3269297	0.64259032	8.172E-6
1	0	3	9659.4364523	0.15930475	0.00012
2	0	2	9877.9339789	0.01432079	4.857E-6
3	0	1	9893.5807004	0.00048509	0.000011
4	0	1	9893.6803551	0.00000468	1.022E-9
5	0	0	9893.6806277	0.00000000	7.021E-7

Convergence criterion (PCONV=1.11022E-8) satisfied.

Fit Statistics	
-2 Res Log Pseudo-Likelihood	9893.68
Generalized Chi-Square	1926.62
Gener. Chi-Square / DF	0.97

Covariance Parameter Estimates					
Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
Intercept	LHIN_pt	0.2885	0.1412	2.04	0.0205

Odds Ratio Estimates						
Variable	Comparator	Referent	DF	OR	95% CI	
gr_SD_CNSSCore	4-8	0-3	25	1.520	0.763	3.026
	>8	0-3	25	1.189	0.583	2.428
DM_LivesWith	Others	Alone	24	0.714	0.541	0.942
	UTD	Alone	24	0.535	0.242	1.184
gr_D_RankinScore	3-5	0-2	19	14.954	10.227	21.865
	Missing	0-2	19	4.723	1.436	15.533
FD_StrokeTypeFinal	Ischemic	ICH	37	0.906	0.585	1.402
	SAH	ICH	37	1.565	0.495	4.946
	UTD	ICH	37	0.438	0.231	0.828
HC_Swallowing	Yes	No	13	1.728	1.317	2.268
LOCArrival	Other	Alert	13	0.583	0.336	1.011
PMH_Asthma	Yes	No	13	0.646	0.428	0.976
PMH_Dementia	Yes	No	13	0.275	0.158	0.478
PMH_Depression	Yes	No	13	0.574	0.371	0.888
PMH_PREEVENTSTATUS	Independent	Dependent	13	2.111	1.528	2.916
PMH_Cancer	Yes	No	13	0.766	0.520	1.127
RegistryArrFrom	Other	Home	13	0.703	0.510	0.968
DM_Age	74.856	73.856	1968	0.994	0.985	1.004

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
gr_SD_CNSSCore	2	25	2.31	0.1197
DM_LivesWith	2	24	3.66	0.0411
gr_D_RankinScore	2	19	111.37	<.0001
FD_StrokeTypeFinal	3	37	3.53	0.0241
HC_Swallowing	1	13	18.92	0.0008
LOCArrival	1	13	4.48	0.0541
PMH_Asthma	1	13	5.24	0.0394
PMH_Dementia	1	13	25.42	0.0002
PMH_Depression	1	13	7.55	0.0166
PMH_PREEVENTSTATUS	1	13	24.96	0.0002
PMH_Cancer	1	13	2.23	0.1592
RegistryArrFrom	1	13	5.66	0.0333
DM_Age	1	1968	1.42	0.2339

Solution for Random Effects								
Effect	Subject	Estimate	Std Err Pred	DF	t Value	Pr > |t|	Lower	Upper
Intercept	LHIN_pt 02	-0.034	0.221	1981	-0.16	0.876	-0.469	0.400
Intercept	LHIN_pt 03	-0.173	0.275	1981	-0.63	0.528	-0.714	0.366
Intercept	LHIN_pt 04	0.005	0.207	1981	0.03	0.978	-0.401	0.412
Intercept	LHIN_pt 05	-0.620	0.306	1981	-2.02	0.043	-1.222	-0.018
Intercept	LHIN_pt 06	-0.386	0.251	1981	-1.54	0.124	-0.878	0.106
Intercept	LHIN_pt 07	0.245	0.227	1981	1.08	0.280	-0.201	0.692
Intercept	LHIN_pt 08	0.029	0.224	1981	0.13	0.894	-0.411	0.470
Intercept	LHIN_pt 09	0.170	0.218	1981	0.78	0.435	-0.257	0.598
Intercept	LHIN_pt 10	-0.169	0.261	1981	-0.65	0.517	-0.682	0.344
Intercept	LHIN_pt 11	0.683	0.235	1981	2.90	0.003	0.221	1.145
Intercept	LHIN_pt 12	-0.869	0.294	1981	-2.95	0.003	-1.447	-0.291
Intercept	LHIN_pt 13	-0.045	0.239	1981	-0.19	0.850	-0.515	0.425
Intercept	LHIN_pt 14	0.063	0.328	1981	0.19	0.846	-0.580	0.707
Intercept	LHIN_pt 01	1.100	0.248	1981	4.43	<.001	0.612	1.588

Cohort 2004/05 Model #3

Data Set	WORK.ADMITTEDPTS
Response Variable	D_Rehab_OSA
Response Distribution	Binary
Link Function	Logit
Variance Function	Default
Variance Matrix Blocked By	LHIN_pt
Estimation Technique	Residual PL
Degrees of Freedom Method	Between-Within

Class Level Information		
Class	Levels	Values
LHIN_pt	14	02 03 04 05 06 07 08 09 10 11 12 13 14 01
gr_SD_CNSSCore	3	2)4-8 3)>8 1)0-3
DM_LivesWith	3	Others UTD Alone
gr_D_RankinScore	3	2)3-5 3)missing 1)0-2
FD_StrokeTypeFinal	4	Ischemic SAH UTD ICH
HC_Swallowing	2	Yes No
LOCArrival	2	Other Alert
PMH_Asthma	2	Yes No
PMH_Dementia	2	Yes No
PMH_Depression	2	Yes No
PMH_PREEVENTSTATUS	2	Independent Dependent
PMH_Cancer	2	Yes No
RegistryArrFrom	2	Other Home

Number of Observations Read	2000
Number of Observations Used	2000

Response Profile		
Ordered Value	D_Rehab_OSA	Total Frequency
1	0	1378
2	1	622

The GLIMMIX procedure is modeling the probability that D_Rehab_OSA='1'.

Dimensions	
G-side Cov. Parameters	1
Columns in X	32
Columns in Z per Subject	1
Subjects (Blocks in V)	14
Max Obs per Subject	248

Optimization Information	
Optimization Technique	Newton-Raphson with Ridging
Parameters in Optimization	1
Lower Boundaries	1
Upper Boundaries	0
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	Restarts	Subiterations	Objective Function	Change	Max Gradient
0	0	5	8998.1654682	0.74015477	0.000029
1	0	3	9670.8137435	0.19266585	0.00039
2	0	2	9889.4620247	0.01889184	0.000016
3	0	1	9905.2110925	0.00068605	0.000026
4	0	1	9905.3145506	0.00000675	2.549E-9
5	0	0	9905.3148424	0.00000000	1.222E-6

Convergence criterion (PCONV=1.11022E-8) satisfied.

Fit Statistics	
-2 Res Log Pseudo-Likelihood	9905.31
Generalized Chi-Square	1932.30
Gener. Chi-Square / DF	0.98

Covariance Parameter Estimates					
Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
Intercept	LHIN_pt	0.1859	0.1006	1.85	0.0324

Odds Ratio Estimates						
Variable	Comparator	Referent	DF	OR	95% CI	
gr_SD_CNSSCore	4-8	0-3	25	1.514	0.760	3.016
	>8	0-3	25	1.182	0.578	2.415
DM_LivesWith	Others	Alone	24	0.716	0.542	0.945
	UTD	Alone	24	0.529	0.239	1.174
gr_D_RankinScore	3-5	0-2	19	14.817	10.147	21.635
	Missing	0-2	19	4.709	1.435	15.451
FD_StrokeTypeFinal	Ischemic	ICH	37	0.898	0.580	1.390
	SAH	ICH	37	1.535	0.486	4.848
	UTD	ICH	37	0.432	0.228	0.817
HC_Swallowing	Yes	No	13	1.723	1.313	2.261
LOCArrival	Other	Alert	13	0.582	0.335	1.009
PMH_Asthma	Yes	No	13	0.647	0.429	0.977
PMH_Dementia	Yes	No	13	0.272	0.156	0.474
PMH_Depression	Yes	No	13	0.576	0.372	0.891
PMH_PREEVENTSTATUS	Independent	Dependent	13	2.095	1.517	2.895
PMH_Cancer	Yes	No	13	0.760	0.516	1.119
RegistryArrFrom	Other	Home	13	0.696	0.505	0.959
DM_Age	74.856	73.856	1968	0.994	0.984	1.004

Odds Ratio Estimates						
Variable	Comparator	Referent	DF	OR	95% CI	
LHIN_BedDaysPerstroke	15.628	14.628	12	1.058	1.009	1.110

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
gr_SD_CNSSCore	2	25	2.33	0.1181
DM_LivesWith	2	24	3.63	0.0419
gr_D_RankinScore	2	19	111.41	<.0001
FD_StrokeTypeFinal	3	37	3.58	0.0229
HC_Swallowing	1	13	18.71	0.0008
LOCArrival	1	13	4.52	0.0532
PMH_Asthma	1	13	5.21	0.0400
PMH_Dementia	1	13	25.72	0.0002
PMH_Depression	1	13	7.46	0.0171
PMH_PREEVENTSTATUS	1	13	24.43	0.0003
PMH_Cancer	1	13	2.35	0.1491
RegistryArrFrom	1	13	5.95	0.0298
DM_Age	1	1968	1.43	0.2315
LHIN_BedDaysPerstrok	1	12	6.69	0.0238

Solution for Random Effects								
Effect	Subject	Estimate	Std Err Pred	DF	t Value	Pr > |t|	Lower	Upper
Intercept	LHIN_pt 02	-0.217	0.211	1980	-1.03	0.304	-0.631	0.197
Intercept	LHIN_pt 03	-0.024	0.256	1980	-0.10	0.922	-0.528	0.478
Intercept	LHIN_pt 04	0.008	0.186	1980	0.05	0.963	-0.356	0.373
Intercept	LHIN_pt 05	-0.086	0.331	1980	-0.26	0.795	-0.736	0.564
Intercept	LHIN_pt 06	-0.459	0.230	1980	-1.99	0.046	-0.912	-0.006
Intercept	LHIN_pt 07	-0.291	0.286	1980	-1.02	0.309	-0.853	0.270
Intercept	LHIN_pt 08	0.312	0.232	1980	1.34	0.180	-0.144	0.768
Intercept	LHIN_pt 09	0.266	0.201	1980	1.32	0.187	-0.129	0.662
Intercept	LHIN_pt 10	-0.231	0.239	1980	-0.96	0.335	-0.701	0.239
Intercept	LHIN_pt 11	0.175	0.276	1980	0.64	0.525	-0.366	0.718
Intercept	LHIN_pt 12	-0.590	0.275	1980	-2.14	0.032	-1.131	-0.049
Intercept	LHIN_pt 13	0.133	0.229	1980	0.58	0.562	-0.317	0.583
Intercept	LHIN_pt 14	0.159	0.299	1980	0.53	0.594	-0.427	0.747
Intercept	LHIN_pt 01	0.844	0.234	1980	3.60	0.00	0.384	1.304

Cohort 2008/09 Model #1

Data Set	WORK.ADMITTEDPTS
Response Variable	D_Rehab_OSA
Response Distribution	Binary
Link Function	Logit
Variance Function	Default
Variance Matrix Blocked By	LHIN_pt
Estimation Technique	Maximum Likelihood
Likelihood Approximation	Laplace
Degrees of Freedom Method	Between-Within

Class Level Information		
Class	Levels	Values
LHIN_pt	14	02 03 04 05 06 07 08 09 10 11 12 13 14 01
DM_Gender	2	Male Female
gr_SD_CNSSCore	3	2)4-8 3)>8 1)0-3
DM_LivesWith	3	Others UTD Alone
gr_D_RankinScore	3	2)3-5 3)missing 1)0-2
PMH_Stroke	2	Yes No
FD_StrokeTypeFinal	4	Ischemic SAH UTD ICH
HC_Swallowing	2	Yes No
LOCArrival	2	Other Alert
PMH_Asthma	2	Yes No
PMH_Dementia	2	Yes No
PMH_Depression	2	Yes No
PMH_PREEVENTSTATUS	2	Independent Dependent
PMH_TIA	2	Yes No
PMH_Diabetes	2	Yes No
PMH_Hypertension	2	Yes No

Class Level Information		
Class	Levels	Values
PMH_Hyperlipidemia	2	Yes No
PMH_SMOKEHISTORY	3	Former Nonsmoker Current
PMH_PulmEdema	2	Yes No
PMH_Carotid	2	Yes No
PMH_Cancer	2	Yes No
PMH_Renal	2	Yes No
PMH_Cirrhosis	2	Yes No
PMH_PeripheralDiseas	2	Yes No
PMH_AtrialFib	2	Yes No
PMH_CAD	2	Yes No
HCP_AtrialFib	2	Yes No
HCP_Pneumonia	2	Yes No
HI_Ng	2	Yes No
HI_FeedingTube	2	Yes No
RegistryArrFrom	2	Other Home

Number of Observations Read	1726
Number of Observations Used	1726

Response Profile		
Ordered Value	D_Rehab_OSA	Total Frequency
1	0	1137
2	1	589
The GLIMMIX procedure is modeling the probability that D_Rehab_OSA='1'.		

Dimensions	
G-side Cov. Parameters	1
Columns in X	68
Columns in Z per Subject	1
Subjects (Blocks in V)	14
Max Obs per Subject	181

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	39
Lower Boundaries	1
Upper Boundaries	0
Fixed Effects	Not Profiled
Starting From	GLM estimates

Iteration History

Iteration	Restarts	Evaluations	Objective Function	Change	Max Gradient
0	0	4	1575.3739165	.	227.3904
1	0	6	1575.3422519	0.03166452	15.42945
2	0	10	1574.5192852	0.82296674	95.7725
3	0	5	1574.5173845	0.00190072	28.43174
4	0	4	1574.188717	0.32866747	2.60454
5	0	4	1573.8017751	0.38694191	15.80713
6	0	3	1573.6551401	0.14663503	9.742493
7	0	3	1573.6099585	0.04518156	13.04966
8	0	2	1573.5957395	0.01421902	13.08869
9	0	4	1573.5639816	0.03175793	4.97534
10	0	3	1573.5440162	0.01996536	0.996823
11	0	3	1573.5327877	0.01122850	7.606644
12	0	3	1573.5270237	0.00576400	6.65797

Iteration History					
Iteration	Restarts	Evaluations	Objective Function	Change	Max Gradient
13	0	2	1573.5255636	0.00146011	1.528371
14	0	4	1573.5215308	0.00403274	0.408069
15	0	3	1573.5191252	0.00240564	2.503845
16	0	3	1573.5182159	0.00090927	4.182501
17	0	2	1573.517601	0.00061492	14.46565
18	0	3	1573.5171954	0.00040566	0.767015
19	0	2	1573.5169878	0.00020757	6.366405
20	0	2	1573.5168245	0.00016331	1.511886
21	0	3	1573.5167259	0.00009859	0.944085
22	0	2	1573.5165805	0.00014540	1.271942
23	0	3	1573.5165328	0.00004765	0.038634
24	0	2	1573.5164917	0.00004114	1.837297
25	0	3	1573.5164663	0.00002543	0.753718
26	0	2	1573.5164253	0.00004092	1.261696
27	0	3	1573.516405	0.00002037	0.058595
28	0	2	1573.5163769	0.00002807	1.431604

Convergence criterion (GCONV=1E-8) satisfied.

Fit Statistics	
-2 Log Likelihood	1573.52
AIC (smaller is better)	1651.52
AICC (smaller is better)	1653.37
BIC (smaller is better)	1676.44
CAIC (smaller is better)	1715.44
HQIC (smaller is better)	1649.21

Fit Statistics for Conditional Distribution	
-2 log L(D_Rehab_OSA | r. effects)	1549.12
Pearson Chi-Square	1658.53
Pearson Chi-Square / DF	0.96

Covariance Parameter Estimates					
Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
Intercept	LHIN_pt	0.1160	0.06949	1.67	0.0476

Odds Ratio Estimates						
Variable	Comparator	Referent	DF	OR	95% CI	
DM_Gender	Male	Female	13	1.152	0.863	1.539
gr_SD_CNSSCore	4-8	0-3	26	0.954	0.488	1.865
	>8	0-3	26	0.928	0.462	1.864
DM_LivesWith	Others	Alone	25	0.727	0.527	1.003
	UTD	Alone	25	1.149	0.620	2.129
gr_D_RankinScore	3-5	0-2	23	19.029	13.249	27.330
	missing	0-2	23	3.441	1.348	8.780
PMH_Stroke	Yes	No	13	0.802	0.567	1.134
FD_StrokeTypeFinal	Ischemic	ICH	39	0.825	0.527	1.292
	SAH	ICH	39	0.361	0.121	1.076
	UTD	ICH	39	0.221	0.101	0.484
HC_Swallowing	Yes	No	13	1.708	1.252	2.329
LOCArrival	Other	Alert	13	0.655	0.358	1.199
PMH_Asthma	Yes	No	13	0.641	0.401	1.024
PMH_Dementia	Yes	No	13	0.189	0.106	0.339
PMH_Depression	Yes	No	13	1.118	0.689	1.815
PMH_PREEVENTSTATUS	Independent	Dependent	13	2.427	1.611	3.656
PMH_TIA	Yes	No	12	1.115	0.725	1.713
PMH_Diabetes	Yes	No	13	1.040	0.744	1.455
PMH_Hypertension	Yes	No	13	1.370	0.984	1.909

Odds Ratio Estimates						
Variable	Comparator	Referent	DF	OR	95% CI	
PMH_Hyperlipidemia	Yes	No	13	0.964	0.704	1.319
PMH_SMOKEHISTORY	Former	Smoker	26	1.063	0.663	1.705
	Non-Smoker	Smoker	26	0.922	0.622	1.366
PMH_PulmEdema	Yes	No	13	1.394	0.827	2.351
PMH_Carotid	Yes	No	11	0.641	0.192	2.143
PMH_Cancer	Yes	No	13	0.884	0.529	1.479
PMH_Renal	Yes	No	13	0.729	0.374	1.419
PMH_Cirrhosis	Yes	No	4	0.002	<0.001	>999.9
PMH_PeripheralDiseas	Yes	No	12	1.606	0.837	3.084
PMH_AtrialFib	Yes	No	13	0.785	0.529	1.165
PMH_CAD	Yes	No	13	0.837	0.593	1.180
HCP_AtrialFib	Yes	No	13	1.108	0.698	1.759
HCP_Pneumonia	Yes	No	12	0.980	0.478	2.008
HI_Ng	Yes	No	13	0.895	0.492	1.629
HI_FeedingTube	Yes	No	12	0.372	0.167	0.827
RegistryArrFrom	Other	Home	13	0.896	0.643	1.250
DM_Age		72.667	1675	0.985	0.974	0.997

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
DM_Gender	1	13	1.12	0.3094
gr_SD_CNSSCore	2	26	0.03	0.9698
DM_LivesWith	2	25	3.07	0.0640
gr_D_RankinScore	2	23	142.59	<.0001
PMH_Stroke	1	13	1.90	0.1912
FD_StrokeTypeFinal	3	39	6.49	0.0011
HC_Swallowing	1	13	13.89	0.0025
LOCArrival	1	13	2.29	0.1544

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
PMH_Asthma	1	13	4.20	0.0611
PMH_Dementia	1	13	38.13	<.0001
PMH_Depression	1	13	0.25	0.6265
PMH_PREEVENTSTATUS	1	13	21.84	0.0004
PMH_TIA	1	12	0.30	0.5920
PMH_Diabetes	1	13	0.07	0.8026
PMH_Hypertension	1	13	4.22	0.0606
PMH_Hyperlipidemia	1	13	0.06	0.8044
PMH_SMOKEHISTORY	2	26	0.31	0.7338
PMH_PulmEdema	1	13	1.89	0.1929
PMH_Carotid	1	11	0.66	0.4348
PMH_Cancer	1	13	0.27	0.6144
PMH_Renal	1	13	1.05	0.3238
PMH_Cirrhosis	1	4	0.59	0.4868
PMH_PeripheralDiseas	1	12	2.51	0.1393
PMH_AtrialFib	1	13	1.76	0.2079
PMH_CAD	1	13	1.25	0.2836
HCP_AtrialFib	1	13	0.23	0.6394
HCP_Pneumonia	1	12	0.00	0.9524
HI_Ng	1	13	0.16	0.6957
HI_FeedingTube	1	12	7.27	0.0194
RegistryArrFrom	1	13	0.50	0.4903
DM_Age	1	1675	6.18	0.0130

Solution for Random Effects								
Effect	Subject	Estimate	Std Err Pred	DF	t Value	Pr > |t|	Lower	Upper
Intercept	LHIN_pt 02	-0.297	0.193	1688	-1.54	0.124	-0.675	0.081
Intercept	LHIN_pt 03	-0.219	0.237	1688	-0.93	0.355	-0.685	0.246
Intercept	LHIN_pt 04	-0.233	0.194	1688	-1.20	0.229	-0.615	0.147
Intercept	LHIN_pt 05	-0.395	0.269	1688	-1.47	0.142	-0.923	0.132
Intercept	LHIN_pt 06	0.215	0.222	1688	0.97	0.332	-0.221	0.653
Intercept	LHIN_pt 07	0.124	0.206	1688	0.61	0.544	-0.279	0.529
Intercept	LHIN_pt 08	-0.029	0.193	1688	-0.15	0.877	-0.409	0.349
Intercept	LHIN_pt 09	0.421	0.205	1688	2.05	0.040	0.017	0.825
Intercept	LHIN_pt 10	-0.228	0.244	1688	-0.93	0.350	-0.708	0.251
Intercept	LHIN_pt 11	0.480	0.224	1688	2.14	0.032	0.040	0.921
Intercept	LHIN_pt 12	-0.299	0.253	1688	-1.18	0.236	-0.795	0.196
Intercept	LHIN_pt 13	0.126	0.214	1688	0.59	0.554	-0.293	0.546
Intercept	LHIN_pt 14	0.089	0.264	1688	0.34	0.734	-0.429	0.608
Intercept	LHIN_pt 01	0.263	0.216	1688	1.22	0.223	-0.160	0.687

Cohort 2008/09 Model #2

Data Set	WORK.ADMITTEDPTS
Response Variable	D_Rehab_OSA
Response Distribution	Binary
Link Function	Logit
Variance Function	Default
Variance Matrix Blocked By	LHIN_pt
Estimation Technique	Residual PL
Degrees of Freedom Method	Between-Within

Class Level Information		
Class	Levels	Values
LHIN_pt	14	02 03 04 05 06 07 08 09 10 11 12 13 14 01
DM_LivesWith	3	Others UTD Alone
gr_D_RankinScore	3	2)3-5 3)missing 1)0-2
PMH_Stroke	2	Yes No
FD_StrokeTypeFinal	4	Ischemic SAH UTD ICH
HC_Swallowing	2	Yes No
LOCArrival	2	Other Alert
PMH_Asthma	2	Yes No
PMH_Dementia	2	Yes No
PMH_PREEVENTSTATUS	2	Independent Dependent
PMH_Hypertension	2	Yes No
PMH_PulmEdema	2	Yes No
PMH_PeripheralDiseas	2	Yes No
HI_FeedingTube	2	Yes No

Number of Observations Read	1726
Number of Observations Used	1726

Response Profile		
Ordered Value	D_Rehab_OSA	Total Frequency
1	0	1137
2	1	589
The GLIMMIX procedure is modeling the probability that D_Rehab_OSA='1'.		

Dimensions	
G-side Cov. Parameters	1
Columns in X	32
Columns in Z per Subject	1
Subjects (Blocks in V)	14
Max Obs per Subject	181

Optimization Information	
Optimization Technique	Newton-Raphson with Ridging
Parameters in Optimization	1
Lower Boundaries	1
Upper Boundaries	0
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	Restarts	Subiterations	Objective Function	Change	Max Gradient
0	0	5	7887.7841425	0.67925964	6.618E-7
1	0	3	8369.8707784	0.14957274	0.00004
2	0	2	8496.7908574	0.01516252	5.751E-6
3	0	1	8503.3211085	0.00056667	0.00002
4	0	1	8503.3593141	0.00000534	1.75E-9
5	0	0	8503.3594878	0.00000000	1.459E-6

Convergence criterion (PCONV=1.11022E-8) satisfied.

Fit Statistics	
-2 Res Log Pseudo-Likelihood	8503.36
Generalized Chi-Square	1666.40
Gener. Chi-Square / DF	0.98

Covariance Parameter Estimates					
Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
Intercept	LHIN_pt	0.1278	0.07539	1.70	0.0450

Odds Ratio Estimates						
Variable	Comparator	Referent	DF	OR	95% CI	
DM_LivesWith	Others	Alone	25	0.731	0.534	1.000
	UTD	Alone	25	1.134	0.618	2.081
gr_D_RankinScore	3-5	0-2	23	18.200	12.945	25.587
	Missing	0-2	23	3.474	1.375	8.772
PMH_Stroke	Yes	No	13	0.797	0.570	1.115
FD_StrokeTypeFinal	Ischemic	ICH	39	0.887	0.572	1.376
	SAH	ICH	39	0.343	0.120	0.982
	UTD	ICH	39	0.243	0.113	0.525
HC_Swallowing	Yes	No	13	1.693	1.251	2.289
LOCArrival	Other	Alert	13	0.671	0.416	1.082
PMH_Asthma	Yes	No	13	0.660	0.423	1.031
PMH_Dementia	Yes	No	13	0.196	0.110	0.348
PMH_PREEVENTSTATUS	Independent	Dependent	13	2.524	1.708	3.729
PMH_Hypertension	Yes	No	13	1.288	0.947	1.752
PMH_PulmEdema	Yes	No	13	1.169	0.717	1.905
PMH_PeripheralDisease	Yes	No	12	1.508	0.803	2.834
HI_FeedingTube	Yes	No	12	0.346	0.180	0.665

Odds Ratio Estimates						
Variable	Comparator	Referent	DF	OR	95% CI	
DM_Age	73.667	72.667	1694	0.983	0.973	0.993

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
DM_LivesWith	2	25	3.06	0.0647
gr_D_RankinScore	2	23	156.34	<.0001
PMH_Stroke	1	13	2.14	0.1677
FD_StrokeTypeFinal	3	39	6.58	0.0010
HC_Swallowing	1	13	14.18	0.0024
LOCArrival	1	13	3.25	0.0946
PMH_Asthma	1	13	4.06	0.0652
PMH_Dementia	1	13	37.54	<.0001
PMH_PREEVENTSTATUS	1	13	26.22	0.0002
PMH_Hypertension	1	13	3.17	0.0982
PMH_PulmEdema	1	13	0.47	0.5029
PMH_PeripheralDiseas	1	12	2.02	0.1812
HI_FeedingTube	1	12	12.53	0.0041
DM_Age	1	1694	10.54	0.0012

Solution for Random Effects								
Effect	Subject	Estimate	Std Err Pred	DF	t Value	Pr > |t|	Lower	Upper
Intercept	LHIN_pt 02	-0.285	0.191	1707	-1.49	0.135	-0.660	0.0892
Intercept	LHIN_pt 03	-0.228	0.235	1707	-0.97	0.331	-0.689	0.232
Intercept	LHIN_pt 04	-0.249	0.193	1707	-1.29	0.195	-0.628	0.128
Intercept	LHIN_pt 05	-0.393	0.249	1707	-1.58	0.114	-0.881	0.094
Intercept	LHIN_pt 06	0.238	0.219	1707	1.08	0.278	-0.192	0.669
Intercept	LHIN_pt 07	0.132	0.206	1707	0.64	0.520	-0.271	0.536
Intercept	LHIN_pt 08	-0.032	0.195	1707	-0.17	0.867	-0.416	0.351
Intercept	LHIN_pt 09	0.424	0.193	1707	2.19	0.028	0.043	0.804
Intercept	LHIN_pt 10	-0.249	0.242	1707	-1.03	0.303	-0.724	0.225
Intercept	LHIN_pt 11	0.491	0.205	1707	2.39	0.016	0.088	0.893
Intercept	LHIN_pt 12	-0.321	0.245	1707	-1.31	0.189	-0.802	0.158
Intercept	LHIN_pt 13	0.105	0.214	1707	0.49	0.623	-0.316	0.527
Intercept	LHIN_pt 14	0.094	0.268	1707	0.35	0.725	-0.432	0.620
Intercept	LHIN_pt 01	0.275	0.209	1707	1.32	0.187	-0.134	0.685

Cohort 2008/09 Model #3

Data Set	WORK.ADMITTEDPTS
Response Variable	D_Rehab_OSA
Response Distribution	Binary
Link Function	Logit
Variance Function	Default
Variance Matrix Blocked By	LHIN_pt
Estimation Technique	Residual PL
Degrees of Freedom Method	Between-Within

Class Level Information		
Class	Levels	Values
LHIN_pt	14	02 03 04 05 06 07 08 09 10 11 12 13 14 01
DM_LivesWith	3	Others UTD Alone
gr_D_RankinScore	3	2)3-5 3)missing 1)0-2
PMH_Stroke	2	Yes No
FD_StrokeTypeFinal	4	Ischemic SAH UTD ICH
HC_Swallowing	2	Yes No
LOCArrival	2	Other Alert
PMH_Asthma	2	Yes No
PMH_Dementia	2	Yes No
PMH_PREEVENTSTATUS	2	Independent Dependent
PMH_Hypertension	2	Yes No
PMH_PulmEdema	2	Yes No
PMH_PeripheralDiseas	2	Yes No
HI_FeedingTube	2	Yes No

Number of Observations Read	1726
Number of Observations Used	1726

Response Profile		
Ordered Value	D_Rehab_OSA	Total Frequency
1	0	1137
2	1	589
The GLIMMIX procedure is modeling the probability that D_Rehab_OSA='1'.		

Dimensions	
G-side Cov. Parameters	1
Columns in X	33
Columns in Z per Subject	1
Subjects (Blocks in V)	14
Max Obs per Subject	181

Optimization Information	
Optimization Technique	Newton-Raphson with Ridging
Parameters in Optimization	1
Lower Boundaries	1
Upper Boundaries	0
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	Restarts	Subiterations	Objective Function	Change	Max Gradient
0	0	5	7894.1195176	0.64912400	4.272E-7
1	0	3	8383.986139	0.14388449	0.000035
2	0	2	8512.4470683	0.01455817	5.206E-6
3	0	1	8518.9570605	0.00053795	0.000018
4	0	1	8518.9921566	0.00000474	1.405E-9
5	0	0	8518.9922945	0.00000000	1.17E-6

Convergence criterion (PCONV=1.11022E-8) satisfied.

Fit Statistics	
-2 Res Log Pseudo-Likelihood	8518.99
Generalized Chi-Square	1670.32
Gener. Chi-Square / DF	0.98

Covariance Parameter Estimates					
Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
Intercept	LHIN_pt	0.1247	0.07445	1.67	0.0470

Odds Ratio Estimates						
Variable	Comparator	Referent	DF	OR	95% CI	
DM_LivesWith	Others	Alone	25	0.738	0.539	1.010
	UTD	Alone	25	1.171	0.637	2.153
gr_D_RankinScore	3-5	0-2	23	18.327	13.025	25.787
	Missing	0-2	23	3.564	1.409	9.016
PMH_Stroke	Yes	No	13	0.801	0.573	1.121
FD_StrokeTypeFinal	Ischemic	ICH	39	0.887	0.572	1.376
	SAH	ICH	39	0.339	0.118	0.973
	UTD	ICH	39	0.245	0.113	0.528
HC_Swallowing	Yes	No	13	1.681	1.243	2.274
LOCArrival	Other	Alert	13	0.672	0.416	1.084
PMH_Asthma	Yes	No	13	0.657	0.421	1.027
PMH_Dementia	Yes	No	13	0.194	0.109	0.344
PMH_PREEVENTSTATUS	Independent	Dependent	13	2.537	1.716	3.751
PMH_Hypertension	Yes	No	13	1.287	0.946	1.751
PMH_PulmEdema	Yes	No	13	1.155	0.708	1.886
PMH_PeripheralDisease	Other	Home	12	1.487	0.790	2.798
HI_FeedingTube	Yes	No	12	0.345	0.179	0.663
DM_Age	73.667	72.667	1694	0.983	0.973	0.993

Odds Ratio Estimates						
Variable	Comparator	Referent	DF	OR	95% CI	
LHIN_BedDaysPerstroke	16.573	15.573	12	1.026	0.984	1.070

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
DM_LivesWith	2	25	3.05	0.0651
gr_D_RankinScore	2	23	156.31	<.0001
PMH_Stroke	1	13	2.03	0.1774
FD_StrokeTypeFinal	3	39	6.56	0.0011
HC_Swallowing	1	13	13.80	0.0026
LOCArrival	1	13	3.23	0.0957
PMH_Asthma	1	13	4.13	0.0629
PMH_Dementia	1	13	37.97	<.0001
PMH_PREEVENTSTATUS	1	13	26.44	0.0002
PMH_Hypertension	1	13	3.14	0.0998
PMH_PulmEdema	1	13	0.40	0.5359
PMH_PeripheralDiseas	1	12	1.87	0.1963
HI_FeedingTube	1	12	12.58	0.0040
DM_Age	1	1694	10.39	0.0013
LHIN_BedDaysPerstrok	1	12	1.79	0.2056

Solution for Random Effects								
Effect	Subject	Estimate	Std Err Pred	DF	t Value	Pr > |t|	Lower	Upper
Intercept	LHIN_pt 02	-0.365	0.199	1706	-1.83	0.067	-0.756	0.025
Intercept	LHIN_pt 03	-0.172	0.237	1706	-0.73	0.467	-0.637	0.292
Intercept	LHIN_pt 04	-0.230	0.192	1706	-1.19	0.232	-0.607	0.147
Intercept	LHIN_pt 05	-0.273	0.263	1706	-1.04	0.299	-0.789	0.243
Intercept	LHIN_pt 06	0.263	0.219	1706	1.20	0.231	-0.167	0.694
Intercept	LHIN_pt 07	-0.109	0.272	1706	-0.40	0.687	-0.644	0.425
Intercept	LHIN_pt 08	0.117	0.225	1706	0.52	0.602	-0.324	0.558
Intercept	LHIN_pt 09	0.526	0.208	1706	2.53	0.011	0.117	0.934
Intercept	LHIN_pt 10	-0.264	0.241	1706	-1.10	0.272	-0.737	0.208
Intercept	LHIN_pt 11	0.356	0.225	1706	1.58	0.114	-0.086	0.799
Intercept	LHIN_pt 12	-0.250	0.249	1706	-1.01	0.314	-0.738	0.238
Intercept	LHIN_pt 13	0.174	0.220	1706	0.79	0.428	-0.257	0.606
Intercept	LHIN_pt 14	0.051	0.268	1706	0.19	0.846	-0.474	0.577
Intercept	LHIN_pt 01	0.175	0.220	1706	0.79	0.426	-0.257	0.607

Curriculum Vitae

Name:	Matthew J. Meyer
Post-secondary Education and Degrees:	The University of Western Ontario/ Queen's University London/Kingston, Ontario, Canada 1999-2004 HBA, Biology and Human Health
	Western University London, Ontario, Canada 2009-2015 Ph.D. (candidate)
Honours and Awards:	Vanier Canada Graduate Scholarship Canadian Institute for Health Research (CIHR) 2012-2015
	Frederick Banting & Charles Best Canada Graduate Scholarship (CIHR) 2012 - Declined
	Carol Buck Graduate Scholarship in Epidemiology Western University; London, Ontario 2010
	Allen and Mary Lou West Memorial Award Queen's University; Kingston, Ontario 2003
	Sandra Letton Quality Award St. Joseph's Healthcare; London, Ontario Stroke Corre Research Team: Rehabilitation Knowledge to Action Project 2014
	Nominated for the Sandra Letton Quality Award St. Joseph's Healthcare; London, Ontario Meyer M, Britt E, McHale H, Teasell R. Length of stay benchmarks for inpatient rehabilitation after stroke. *Disability and Rehabilitation* 2012: 34 (13): 1077-81.
	Best Overall Poster Award: Meyer M, McClure A, Pan C, Murie-Fernandez M, Foley N, Salter K, Teasell R. Economic review of

stroke rehabilitation in Ontario: Improving efficiency to optimize outcomes. 57th Annual Meeting of Canadian Association of Physical Medicine and Rehabilitation, Banff, Alberta, May 27-30, 2009 abstract A43, p. 40.

Best Review Poster Category Award: Meyer M, McClure A, Pan C, Murie-Fernandez M, Foley N, Salter K, Teasell R. Economic review of stroke rehabilitation in Ontario: Improving efficiency to optimize outcomes. 57th Annual Meeting of Canadian Association of Physical Medicine and Rehabilitation, Banff, Alberta, May 27-30, 2009 abstract A43, p. 40.

Related Work Experience/ Professional Activity

April 2014 – March 2015: South Western Ontario Stroke Network –Data Support/ Epidemiology Services – London, Ontario

February 2014 – present: Ontario MoHLTC – Stroke Capacity Planning Steering Committee - Toronto, Ontario

November 2014 - present: Ontario Rehabilitative Care Alliance System Evaluation Indicator Working Group - Toronto, Ontario

September 2013 – present: Ontario Rehabilitative Care Alliance Capacity Planning and Service Evaluation Task Group - Toronto, Ontario

September 2013 – present: Ontario Rehabilitative Care Alliance Planning Considerations for Re-designation of CCC/Rehabilitation Beds Task Group - Toronto, Ontario

September 2013 – present: Ontario Rehabilitative Care Alliance – Outpatient/ Ambulatory Task Group - Toronto, Ontario

August 2012 – present: Health Quality Ontario: Stroke ‘Episode of Care’ Expert Panel phase II - Toronto, Ontario

June 2011- present: Ontario Stroke Network: Project Coordinator, Stroke Rehabilitation Best Practices in Ontario - London, Ontario

May 2008-present: Lawson Health Research Institute: Aging, Rehabilitation and Geriatric Care Research Centre; Research Coordinator - London, Ontario

December 2014 – August 2014: North Simcoe Muskoka LHIN – Rehabilitative Care Capacity Project Consultant - Orillia, Ontario

February 2012 – August 2013: Health Quality Ontario: Stroke Expert Advisory Panel - Toronto, Ontario

November 2011- January 2013: Ontario MoHLTC: Ontario Data Availability and Use Working Group of the Rehabilitation and Complex Continuing Care Expert Panel -
Toronto, Ontario

May 2006-August 2008: Dale Brain Injury Services: Rehabilitation Counsellor - London, Ontario

February 2007-January 2008: Illawara Disability Trust: Personal Support Worker - Wollongong, NSW, Australia

Related Publications:

Meyer M, Pereira S, McClure A, Teasell R, Thind A, Koval J, et al. A systematic review of studies reporting multivariable models to predict functional outcomes after post-stroke inpatient rehabilitation. *Disability and Rehabilitation* 2014; Sept 24:1-8 [Epub ahead of print].

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Matthew Meyer, Laura Allen. Assessing the impact of Southwestern Ontario's Community Stroke Rehabilitation Teams: An economic analysis. Stroke Collaborative Toronto, ON. October 28, 2013.

Meyer M, McClure A, O'Callaghan C, Kelloway L, Hall R, Bayley M, Teasell R. A regional assessment of the economics of stroke care in Ontario. 3rd Canadian Stroke Congress Montreal, QB. October 17-20, 2013.

Matthew Meyer. Keynote address: An economic evaluation of stroke care in the Champlain LHIN. Champlain Interprofessional Stroke Education Day. Ottawa, ON. September 30, 2013

Matthew Meyer. Economic Overview – SW and ESC LHINs. Meeting of the Southwestern Ontario Stroke Network Steering Committee. London, ON. June 12, 2013.

Dr. Mark Bayley, Cheryl Moher, Matthew Meyer. Stroke System Design in North Simcoe Muskoka. Physician information session. May 24, 2013.

M Meyer. The impact of resource availability on patterns of referral to inpatient rehabilitation after stroke. 2013 PM&R Resident Research Day; Parkwood Hospital, London, ON, Apr 15, 2013.

M Meyer. The impact of post-stroke rehabilitation on 2-year healthcare costs in Ontario, Canada: Can rehabilitation save us money? 2013 International Stroke Conference; Honolulu, Hawaii, Feb 6 2013.

M Meyer. The economics of stroke care in Ontario. West GTA Stroke Network; Mississauga Ontario, January 24th 2013.

Meyer M. Evaluating Ontario's Stroke Rehabilitation System: Challenges and Possibilities

- Heart and Stroke Foundation of Ontario Stroke Collaborative; Toronto, Ontario, October 15, 2012
- Parkwood Hospital Physical Medicine and Rehabilitation Grand Rounds; London, Ontario, September 17, 2012

Meyer M. The impact of moving to stroke rehabilitation best practices in Ontario: A preliminary report.

- North Simcoe Muskoka Value Stream Mapping Initiative; Orillia, Ontario, June 6, 2012.
- Southwestern Ontario Stroke Rehabilitation Forum; London, Ontario, April 26, 2012.
- Central East Stroke Network's Spring 2012 Symposium; Oshawa, Ontario, April 4, 2012.
- Stroke Rehabilitation and Beyond; Hamilton, Ontario, April 3, 2012.
- Ontario Stroke Network Provincial Rounds; London, Ontario, February 23, 2012.
- Ministry of Health and Long-Term Care, Toronto, Ontario, January 12, 2012.

Meyer M, Teasell R, Thind A, Koval J, Speechey M. Mild Stroke: Do Community-based Resources Impact Rates of Admission to Inpatient Rehabilitation? London Health Research Day; London, Ontario, March 20, 2012.

Meyer M, Britt E, McHale H, Teasell R. Length of stay benchmarks for inpatient rehabilitation after stroke; A Canadian perspective.

- GTA Best Practices Day 2012, Toronto, Ontario, February 27, 2012.
- GTA Rehabilitaiton Network, Stroke Flow Education Session, Providence Healthcare, Toronto, Ontario, January 18, 2012.

Meyer M. Stroke Rehabilitation in Ontario: The Impact of Resource Availability on Regional Accessibility. UWO Department of Epidemiology and Biostatistics Seminar Series; London, Ontario, January 27, 2012.

Meyer M Pereira S, McClure A, Foley N, Salter K, Willems D, Hall R, Asllani E, Fang J, Speechley M, Teasell R. An Economic Model for Stroke Rehabilitation in Ontario: Mapping Resource Availability and Patient Needs.

- Ontario Ministry of Health and Long-Term Care 2011 Health Research Showcase, Toronto, Ontario, December 1, 2011
- Provincial Stroke Rounds hosted by the Central East Stroke Network, June 1, 2011
- Southwestern Ontario Stroke Rehabilitation Advisory Group, London, Ontario, April 12, 2011
- OSS regional stroke rehabilitation coordinators group, London, Ontario, April 11, 2011

Meyer M, M Bayley. Impact of rehabilitation on alternate level of care (ALC) and ER.

- Mosaic of Stroke: Moving from Knowledge to Action, Oshawa, Ontario, November 22, 2011
- Heart and Stroke Foundation Stroke Collaborative, Toronto, Ontario, October 17, 2011

Meyer M, Pan C, McClure A, Foley N, Salter K, Mehta S, McHale H, Hall R, Lee D, Murie-Fernandez M, Teasell R. An economic review of stroke rehabilitation in Ontario: Improving efficiency to optimize outcomes. Showcase Health Policy Initiative at Western, London, Ontario, May 2009

Relevant Poster Presentations as First Author

Meyer M, Sooley D, Tee A, Morrison K, McConnachie S, Gallardi A, et al. Assessment of Key Variables Related to Investment in Outpatient and Community-Based Rehabilitation for Stroke Patients in the North Simcoe Muskoka LHIN Health Quality Ontario Transitions Toronto, Ontario 2014.

Meyer M, Sooley D, Tee A, Morrison K, McConnachie S, Gallardi A, et al. Developing a Decision-Making Model for Investment in Outpatient and Community-Based Rehabilitation for Stroke Patients in North Simcoe Muskoka. Canadian Stroke Congress, Vancouver, Canada 2014.

Meyer M, Teasell R, Thind A, Koval J, Speechey M. Mild Stroke: Do Community-based Resources Impact Rates of Admission to Inpatient Rehabilitation? Canadian Student Health Research Forum (CSHRF), Winnipeg, MN 2012.

Meyer M, Thind A, Speechley M, Koval J, Teasell R. Mild stroke; Do community-based resources impact rates of admission to inpatient rehabilitation? American Congress of Rehabilitation Medicine and the American Society of Neurorehabilitation Joint Education Conference (ACRM-ASNR), Vancouver, BC 2012.

Meyer M, O'Callaghan C, Kelloway L, Bayley M, Hall R, Fang J, et al. Inpatient rehabilitation after stroke: Are patients staying too long? 3rd Canadian Congress of Stroke, Calgary, Alberta 2012.

Meyer M, O'Callaghan C, Kelloway L, Bayley M, Hall R, Fang J, et al. Travel times for post-stroke rehabilitation among patients living in the community in Ontario. 3rd Canadian Congress of Stroke. Calgary, Alberta 2012.

Meyer M, Donaldson S, Leci E, Salter K, Foley N, Allen L, et al. Management of hypertension during post-stroke rehabilitation: Are we doing enough? London Health Research Day, London, Ontario, 2012.

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Meyer M, Britt E, McHale H, Teasell R. Length of stay benchmarks for inpatient rehabilitation after stroke; A Canadian perspective. UWO Knowledge Synthesis/ Knowledge Translation Symposium, London, Ontario 2011.

Meyer MJ, Teasell R, Thind A, Koval J, Speechey M. Early supported discharge in post-stroke inpatient rehabilitation: Who and what are we talking about? International Stroke Conference, New Orleans, LA, USA, 2012.

Meyer M, Britt E, McHale H, Teasell R. Length of stay benchmarks for inpatient rehabilitation after stroke; A Canadian perspective. Stroke Collaborative, Toronto, Ontario, 2011.

Meyer M, Pereira S, McClure A, Salter K, Foley N, Lee D, et al. Predicting Functional Independence After Post-Stroke Rehabilitation: A Systematic Review of Multivariable Models. Stroke Collaborative, Toronto, Ontario, 2011.

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