1-22-2019 1:00 PM

Modelling clinical decision-making referral patterns to home-based or hospital-based stroke outpatient rehabilitation programs in London, Ontario: A prognostic model development study

Jerome Iruthayarajah, *The University of Western Ontario*

Supervisor: Speechley, Mark R, *The University of Western Ontario*
Co-Supervisor: Teasell, Robert W, *The University of Western Ontario*
A thesis submitted in partial fulfillment of the requirements for the Master of Science degree in Epidemiology and Biostatistics

Abstract

The rehabilitation of stroke survivors is an ongoing process for months to years after the injury. Parkwood Institute in London, Ontario is an example of a model outpatient program recommended by the Canadian Stroke Best Practice Recommendations, as patients have access to hospital-based outpatient rehabilitation (Comprehensive Outpatient Rehabilitation Program (CORP)) and home-based rehabilitation (Community Stroke Rehabilitation Teams (CSRT)). However, the decision to refer to either outpatient service is ad hoc. This thesis explores if referrals to CORP or CSRT can be modelled through the development of a prognostic model. The model found that patients who have a higher number of comorbidities, live further away from Parkwood Institute, are older, have strokes of moderate severity, lower functional independence measure (FIM) scores and have reading comprehension difficulties are referred more often to CSRT. Patients with a caregiver, higher FIM scores, and auditory communication problems are more likely to be referred to CORP.

Keywords

Stroke, rehabilitation, outpatient, prediction model, prognostic, referral, decision-making, logistic regression

Acknowledgements

I would like to extend my sincerest gratitude to the following people for their contributions in helping me produce this thesis.

My fellow cohort members in the Epidemiology and Biostatistics MSc program for their encouragement and motivation.

The faculty members of the Epidemiology and Biostatistics department for their tutelage during courses.

The CORRE research group, I have been very fortunate to work with this dedicated group of individuals for the past five years. All of you have imparted on me, valuable lessons about research and life throughout the years.

The CORP and CSRT rehabilitation teams for allowing us the opportunity to use their data for this project.

The Parkwood Institute endowment committee and London Life Insurance Company for their financial support during my graduate studies.

My advisory committee, Dr. Mark Speechley for your unwavering support and guidance during the thesis from its conception to execution. Your mentorship and feedback helped me produce a thesis I am proud of and gave me a deeper appreciation of the field of epidemiology.

Dr. Matthew Meyer, whose guidance made me think critically about my project from the refinement of my research question to its impact on the rehabilitation system. You have been a role model of mine, so I am humbled I got the opportunity to learn from you.

Dr. Robert Teasell, you have done so much for me over the years. The positive impact you have had on my life since I stumbled into your research lab is tremendous. Thank you for giving me a space to grow as a researcher and as an individual, while showing me the beauty of neurorehabilitation.

Lastly, I would like to thank two individuals who have been pivotal to my success as a researcher: Amanda McIntyre and Shannon Janzen. You two took a chance on me so many years ago when you taught me the principles of neurorehabilitation research. Many of my greatest accomplishments I owe to your support and guidance.

Table of Contents

List of Tables

List of Figures

List of Appendices

Chapter 1: Background Information

1.0 Introduction to Strokes

The American Heart and Stroke Association defines a stroke as a neurological deficit produced by a focal vascular injury in the brain that can occur from ischemia, hemorrhages and central venous thrombosis.[1] Ischemic strokes are characterized by central nervous system infarctions, which are areas of cell death and necrosis from a lack of blood supply and oxygen due to the thrombosis of arteries in these cerebrovascular regions.[1] By contrast, hemorrhagic strokes are characterized by the bursting of blood vessels in the brain that can cause bleeding within the brain parenchyma, subarachnoid space and ventricular systems.[1]

In Canada the estimated annual incidence of new stroke cases is 62,000 per year, while over 315,000 Canadians currently live with its complications.[2,3] It is estimated that the cost of stroke care to the Canadian health care system is over $3.6 billion in terms of hospital expenses and opportunity costs.[2] Of those who have a stroke in Canada, 80% will survive, and the management of the sequelae caused by a stroke are the greatest burden to the patient, their families, and the health care system.[4,5] Dependent on the brain region affected and the size of the lesion, deficits caused by a stroke are heterogeneous. The severity of these deficits may be transient or persist for the rest of a stroke survivor's life. Impairments can include but are not limited to: physical disabilities in the upper and lower extremities, hemiparesis and hemiplegia, disruptions to psychological well-being, aphasia, apraxia, spasticity, dysphagia, cognitive dysfunction, perceptual disorders and incontinence.[2] A more in-depth classification of the disabilities caused by a stroke can be seen in the World Health Organization (WHO)'s framework for the international classification of function, disability and health for stroke survivors (Figure 1). The prevalence of stroke-related burden is projected to increase substantially in the next two decades.[5] As such, stroke is a leading cause of death and disability in Canada.

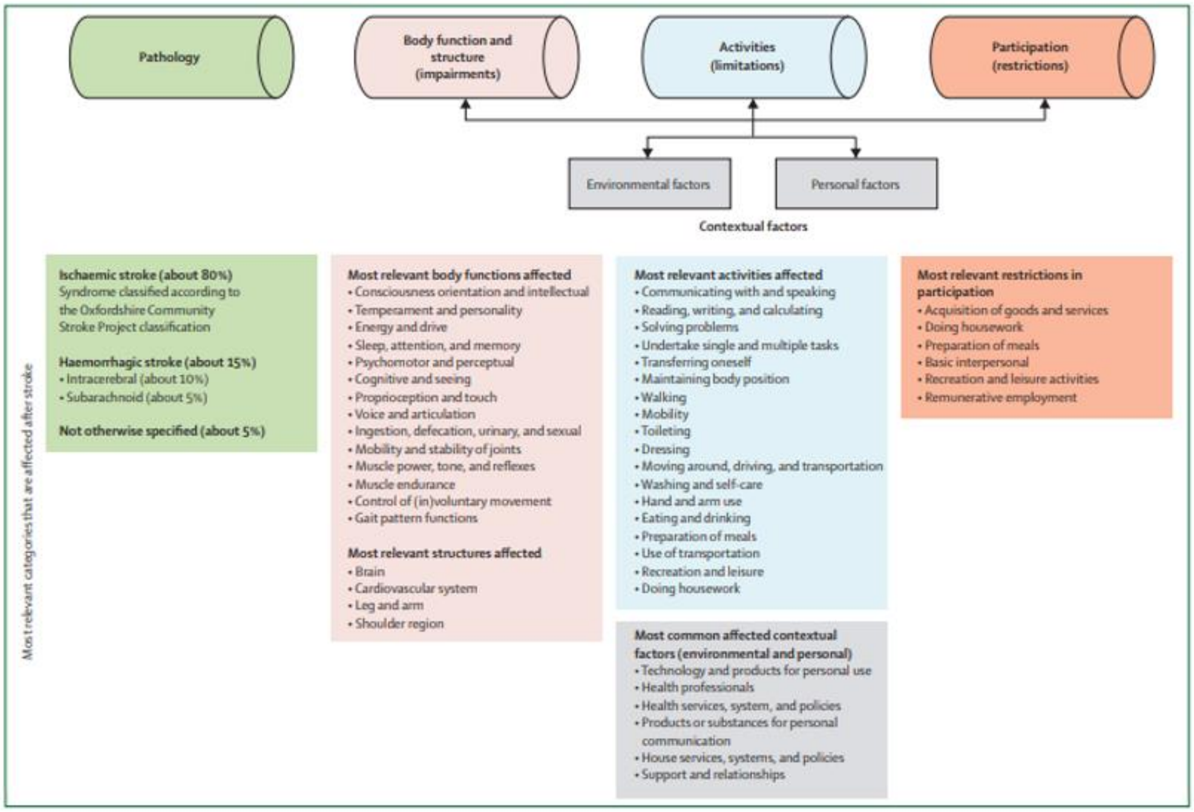


Figure 1. The international classification, disability and health framework for the effect of stroke on an individual (adopted from [5]). This figure summarises key features of WHO's international classification of function, disability, and health model; for the most relevant categories affected after stroke.

Fortunately, specialized stroke rehabilitation has been proven to be a viable option for stroke survivors in improving their ongoing deficits experienced during both the acute (less than 1 month after injury) and chronic (greater than 6 months after injury) phases of the injury.[5,6] The number needed to treat in specialized stroke units to prevent a death or long-term care institutionalization are 1 in 33 patients, and 1 in 20 patients respectively; rehabilitation as such can benefit the patient tremendously.[7] Recognizing the value of rehabilitation, clinicians, researchers and policy makers have collaborated in creating a set of guidelines for the management of acute and long term stroke care in Canada called the Canadian Stroke Best Practice Recommendations.[2] These guidelines provide clinical and evidence-based recommendations for the management of stroke survivors during acute care, inpatient and outpatient rehabilitation.

1.1 Stroke Rehabilitation in Ontario, Canada

Ontario is the most populous province of Canada and accounts for 40% of the annual new stroke cases in Canada.[8] The pathway of care for stroke survivors in Ontario follows a typical trajectory. After experiencing a stroke, patients are rushed to an emergency department and then shortly admitted to an acute care facility where they undergo diagnostic testing and emergency medical management.[9] Patients undergo comprehensive assessments of their cognitive and functional status to formulate individualised plans of care and recovery.[2] Once a patient's condition has stabilised, a decision about where to discharge the patient is made collaboratively by the rehabilitation physician, clinicians on site, the patient themselves and family members. The discharge destination of the patient from acute care can vary from: sending the patient home with no services, inpatient rehabilitation, outpatient rehabilitation and institutional care organizations (i.e. long term care facilities; complex continuing care) (Figure 2). This discharge decision is influenced by non-clinical factors such as the proximity of facilities, bed or program availability, and the engagement and expertise of care providers.[10,11] The majority of patients will however be discharged to inpatient rehabilitation following acute care for their ongoing impairments.[9] Accordingly, inpatient stroke rehabilitation receives the bulk of healthcare funding in Ontario relative to other care pathways.[12]

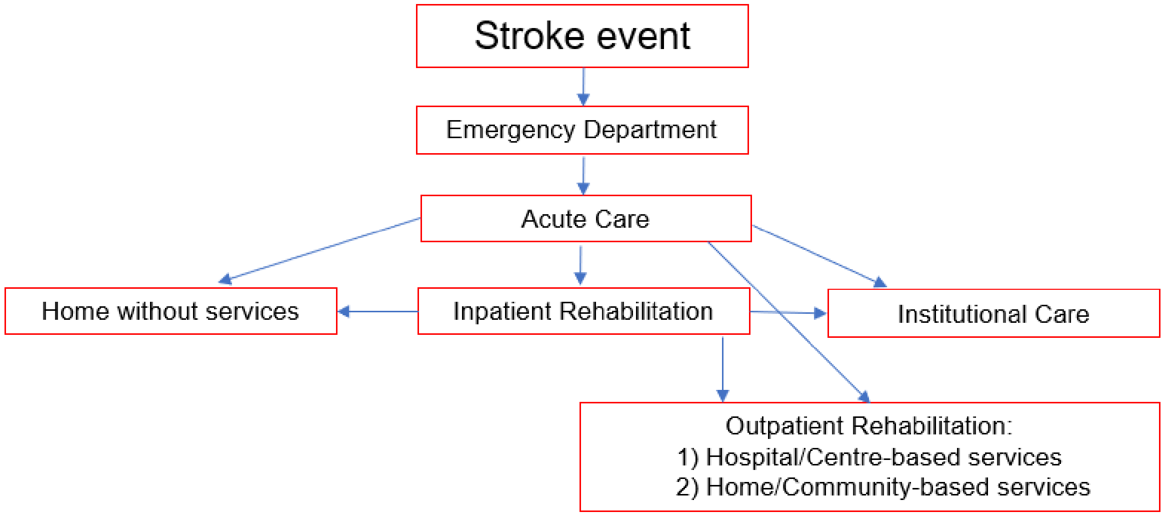


Figure 2. Care pathway trajectories for a stroke survivor in Ontario.

Inpatient stroke rehabilitation units are composed of multidisciplinary teams with commonly, the following members:

Physiatrist: A medical professional practicing in physical medicine and rehabilitation that provides neurological expertise about each stroke case admitted to the unit. The physiatrist approves rehabilitation programs for each case. The physiatrist is involved in discharge planning and organization of further services at the outpatient level.[7]

Physiotherapists: Administer therapies and exercises to improve a patient's mobility, strength and physical activity in both the upper and lower extremities during rehabilitation.[7]

Occupational therapists: Incorporate principles of sensory, motor, cognitive and affective rehabilitation to improve a patient's activities of daily living. Therapies involve compensatory strategies to promote independence and are usually done through activities that are meaningful to the patient.[13]

Speech language pathologists: Specialize in the treatment of oral, language and communication disorders including aphasia, dysphagia and dysarthria.[14]

Dietitians: Provide patients with dietary and nutrition plans that are appropriate to their impairment needs.[15]

Nurses: Assist patients with activities of daily living and provide immediate medical management (i.e. splinting, medication administration, catheter installation), physiological monitoring (i.e. blood pressure readings, incontinence checks), health education and can perform a variety of assessments for activities of daily living.[16]

Recreational therapist: Focus on remediating quality of life of the patient, through encouragement and participation in recreation and leisure activities.[15]

Social workers: Focus on discharge planning and, identify and work through issues patients have with substance abuse, marital status, mental health, returning to work and driving.[15]

Stoke rehabilitation is a dynamic, cyclical, goal-oriented process consisting of: assessing the patient's needs, goal setting, interventions to assist in the achievement of goals, and re-assessment.[5] As stroke cases can be heterogeneous, a rehabilitation program is tailored specifically to each stroke survivor. Members of the team meet weekly to discuss patient progress, rehabilitation goals and potential discharge arrangements; doing so allows these individualized rehabilitation programs to be flexible and updated based on the patient's status.[2] The efficacy of inpatient rehabilitation on patient outcomes has been well-documented in the literature.[17,18] Specialized stroke rehabilitation units when compared to general rehabilitation units result in statistically significant greater improvements in patients' functional independence, quality of life, and reductions in mortality.[2] In Ontario, patients' length of stay in inpatient rehabilitation is determined using benchmarks based on quality-based procedures called rehabilitation patient groups, where length of stay can vary from 1 to 49 days.[19]

After a patient has completed their inpatient rehabilitation length of stay, a referral to outpatient services may then be considered. Traditionally outpatient rehabilitation programs in Ontario were limited by resources and prone to budget cuts.[12] However, the Canadian Stroke Best Practice Recommendations advocate for the identification and referral of patients who would benefit from outpatient rehabilitation programs, as the deficits of a stroke are not just experienced in the acute phase of the injury but may persist in the chronic phase for months or years after the incident.[2] Outpatient rehabilitation uses the same multidisciplinary services as inpatient rehabilitation to assess and track rehabilitation goals, but these services can be provided in a hospital or a home setting. The provision of outpatient services is where regional differences emerge more prominently in Ontario.

1.2 The Southwest Local Health Integration Network (LHIN) and outpatient rehabilitation

As part of the regionalization of health care services, Ontario is split into 14 Local Health Integration Networks (LHINs); the boundaries of these LHINs were designed to capture smaller, homogenous regions of the province to aid in the delivery of appropriate and efficient health care services according to the needs of the local population. In practice, LHINs have effectively led to the evolution of 14 moderately different stroke systems (Figure 3).[20]

Figure 3. The boundaries of Ontario's LHINs (adopted from [21]).

The second LHIN or Southwest LHIN is home to nearly a million residents and captures Grey, Bruce, Huron, Perth, Middlesex, Oxford, Elgin and Norfolk counties (Figure 4).[22]

Figure 4. The Southwest LHIN (adopted from [22]).

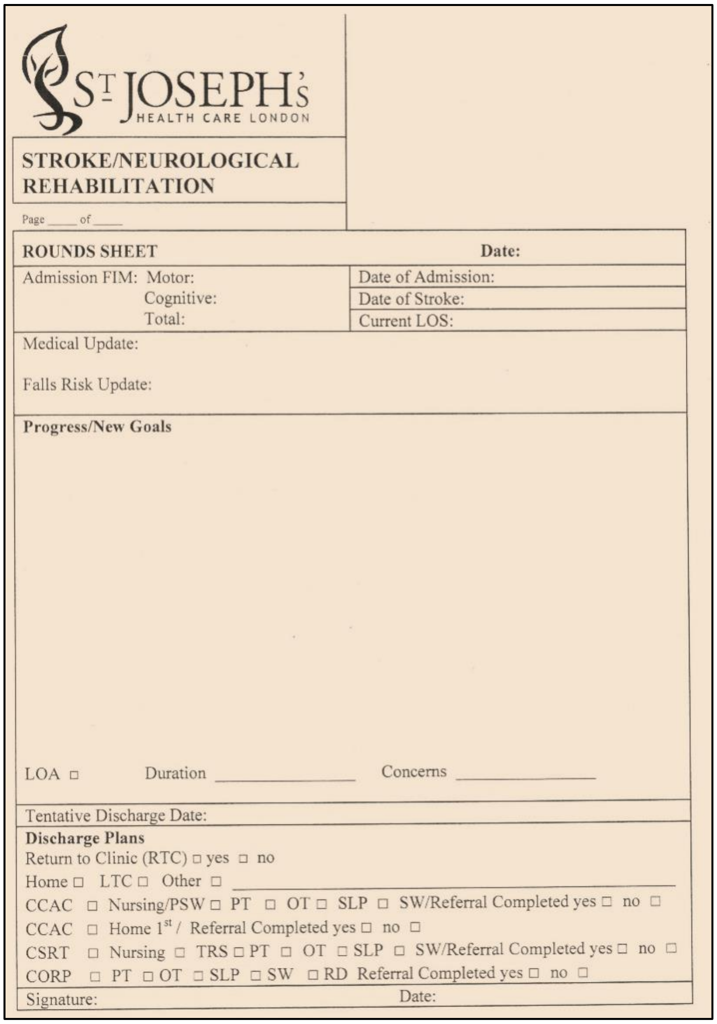
All residents of the Southwest LHIN who experience a recognized stroke are admitted to one of seven designated stroke centres across the LHIN for acute care and inpatient rehabilitation.[23] The provision of outpatient rehabilitation services however varies within the Southwest LHIN. Before 2009, multidisciplinary stroke outpatient rehabilitation services were provided solely in a hospital setting. These hospital-based outpatient rehabilitation centres were located in urban areas of the Southwest LHIN, resulting in many rural patients (as high as >50%) being unable to access these services following discharge from acute care and inpatient rehabilitation because of transportation barriers.[24,25]

To overcome these geographical limitations, in 2009 the Community Stroke Rehabilitation Teams (CSRT) were created to provide home-based, multidisciplinary stroke outpatient rehabilitation to patients in their home or community.[26] CSRT provides services to all patients in the eight counties of the Southwest LHIN through three teams. The Thames Valley team working out of London, Ontario provides care to the counties of Middlesex, Oxford, Elgin and parts of Norfolk; the Huron-Perth team works out of Seaforth, Ontario and provides service to Huron and Perth counties; and the Owen Sound team provides service to Grey and Bruce counties.[26] CSRT has been shown to improve functional and psychosocial outcomes in patients, and caregiver burden, regardless if the patient is from a rural or urban area.[27,28] Additionally, cost-effectiveness analyses have shown that CSRT when compared to patients who receive no outpatient care, has a net monetary benefit of $43,655, a cheaper incremental cost (-$17,255) and a 1.65 gain in quality adjusted life years.[29]

The creation of CSRT effectively dichotomized outpatient rehabilitation within the Southwest LHIN to hospital-based or home-based outpatient rehabilitation, in accord with what is recommended by the Canadian Stroke Best Practice Recommendations that patients should be able to access either of these services.[2] However, not all areas in the Southwest LHIN have access to both outpatient services. London, Ontario is an example of a city in which patients who attend inpatient rehabilitation at Parkwood Institute have access to both a home-based outpatient rehabilitation (CSRT) and a hospital-based outpatient rehabilitation program. The hospital-based outpatient rehabilitation program offered at Parkwood Institute is the Comprehensive Outpatient Rehabilitation Program (CORP). CORP like CSRT offers a multidisciplinary approach to rehabilitation, but these services are offered in a single location. A major benefit of this arrangement is that patients can utilise a range of therapists and equipment not suitable for portable travel (i.e. exoskeletons, treadmills) at each visit, and progress can be monitored judiciously by clinicians on site with real-time feedback.[30] Additionally, there is no incurred health care costs of therapists travelling to patients' homes. CORP has been shown to improve patients' functional, upper extremity, and mobility outcomes, and is effective in achieving rehabilitation goals.[30,31]

1.3 Outpatient referral decision-making

Once a patient's inpatient rehabilitation length of stay is close to completion at Parkwood Institute, the multidisciplinary team will meet at a final team rounds and decide discharge plans for the patient. The physiatrist will inquire from each team member about the status of the patient in each discipline's area of expertise, fill out a form summarizing the patient's progress during rehabilitation, and outline any discharge plans (Figure 5).



ST JOSEPH'S HEALTH CARE LONDON

STROKE/NEUROLOGICAL REHABILITATION

Page ____ of ____

ROUNDS SHEET — Date:

Admission FIM: Motor: / Cognitive: / Total:

Date of Admission:

Date of Stroke:

Current LOS:

Medical Update:

Falls Risk Update:

Progress/New Goals

LOA □ Duration ______________ Concerns ______________

Tentative Discharge Date:

Discharge Plans

Return to Clinic (RTC) □ yes □ no

Home □ LTC □ Other □ ______________

CCAC □ Nursing/PSW □ PT □ OT □ SLP □ SW/Referral Completed yes □ no □

CCAC □ Home 1st / Referral Completed yes □ no □

CSRT □ Nursing □ TRS □ PT □ OT □ SLP □ SW/Referral Completed yes □ no □

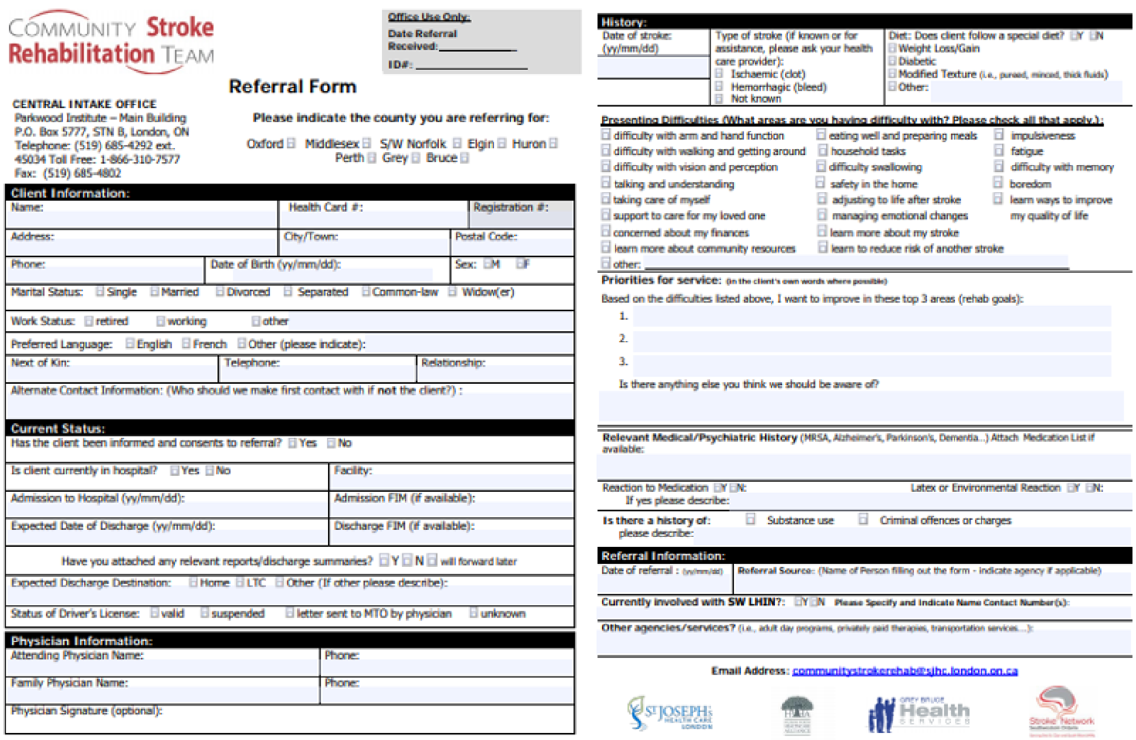
CORP □ PT □ OT □ SLP □ SW □ RD Referral Completed yes □ no □

Signature: Date:

Figure 5. Discharge form used for inpatient rehabilitation at Parkwood Institute, London, Ontario.

If a decision is made for the patient to receive outpatient services, a referral form will be completed for either CORP or CSRT (Figure 6; Figure 7). The referral forms are similar in that they ask what the patient's rehabilitation goals are, services that are needed and contact information for the referring physician. Because patients are evaluated for suitability for outpatient rehabilitation on a case by case basis, the process is very much ad hoc. But common themes for why patients are referred to CSRT over CORP include: transportation barriers (i.e. unable to drive, cost of transportation, or no caregiver to provide them a ride), the distance to travel to Parkwood Institute is too far, or simply the patient or their caregiver would prefer for the rehabilitation to be delivered at home.

Consequently, this process can potentially lead to systematic differences in the types of patients who are referred to each service. Given that a model outpatient system recommended by the Canadian Stroke Best Practices is one where patients have access to both home-based and hospital-based services, comparisons between the two are warranted to prioritize resource allocation and influence future stroke care infrastructure. However, in a real-world setting, comparisons between the two programs may be confounded if the comparator groups themselves differ considerably in both clinical and non-clinical characteristics.


Community Stroke Rehabilitation Team

Office Use Only:
Date Referral Received: ____________
ID#: ____________

Referral Form

CENTRAL INTAKE OFFICE
Parkwood Institute – Main Building
P.O. Box 5777, STN B, London, ON
Telephone: (519) 685-4292 ext. 45034 Toll Free: 1-866-310-7577
Fax: (519) 685-4802

Please indicate the county you are referring for:
Oxford ☐ Middlesex ☐ S/W Norfolk ☐ Elgin ☐ Huron ☐ Perth ☐ Grey ☐ Bruce ☐

Client Information:
Name: | Health Card #: | Registration #:
Address: | City/Town: | Postal Code:
Phone: | Date of Birth (yy/mm/dd): | Sex: ☐M ☐F
Marital Status: ☐ Single ☐ Married ☐ Divorced ☐ Separated ☐ Common-law ☐ Widow(er)
Work Status: ☐ retired ☐ working ☐ other
Preferred Language: ☐ English ☐ French ☐ Other (please indicate):
Next of Kin: | Telephone: | Relationship:
Alternate Contact Information: (Who should we make first contact with if **not** the client?) :

Current Status:
Has the client been informed and consents to referral? ☐ Yes ☐ No
Is client currently in hospital? ☐ Yes ☐ No | Facility:
Admission to Hospital (yy/mm/dd): | Admission FIM (if available):
Expected Date of Discharge (yy/mm/dd): | Discharge FIM (if available):
Have you attached any relevant reports/discharge summaries? ☐ Y ☐ N ☐ will forward later
Expected Discharge Destination: ☐ Home ☐ LTC ☐ Other (If other please describe):
Status of Driver's License: ☐ valid ☐ suspended ☐ letter sent to MTO by physician ☐ unknown

Physician Information:
Attending Physician Name: | Phone:
Family Physician Name: | Phone:
Physician Signature (optional):

History:
Date of stroke: (yy/mm/dd)
Type of stroke (if known or for assistance, please ask your health care provider): ☐ Ischaemic (clot) ☐ Hemorrhagic (bleed) ☐ Not known
Diet: Does client follow a special diet? ☐Y ☐N ☐ Weight Loss/Gain ☐ Diabetic ☐ Modified Texture (i.e., pureed, minced, thick fluids) ☐ Other:

Presenting Difficulties (What areas are you having difficulty with? Please check all that apply.):
☐ difficulty with arm and hand function ☐ eating well and preparing meals ☐ impulsiveness
☐ difficulty with walking and getting around ☐ household tasks ☐ fatigue
☐ difficulty with vision and perception ☐ difficulty swallowing ☐ difficulty with memory
☐ talking and understanding ☐ safety in the home ☐ boredom
☐ taking care of myself ☐ adjusting to life after stroke ☐ learn ways to improve my quality of life
☐ support to care for my loved one ☐ managing emotional changes
☐ concerned about my finances ☐ learn more about my stroke
☐ learn more about community resources ☐ learn to reduce risk of another stroke
☐ other:

Priorities for service: (in the client's own words where possible)
Based on the difficulties listed above, I want to improve in these top 3 areas (rehab goals):
1.
2.
3.
Is there anything else you think we should be aware of?

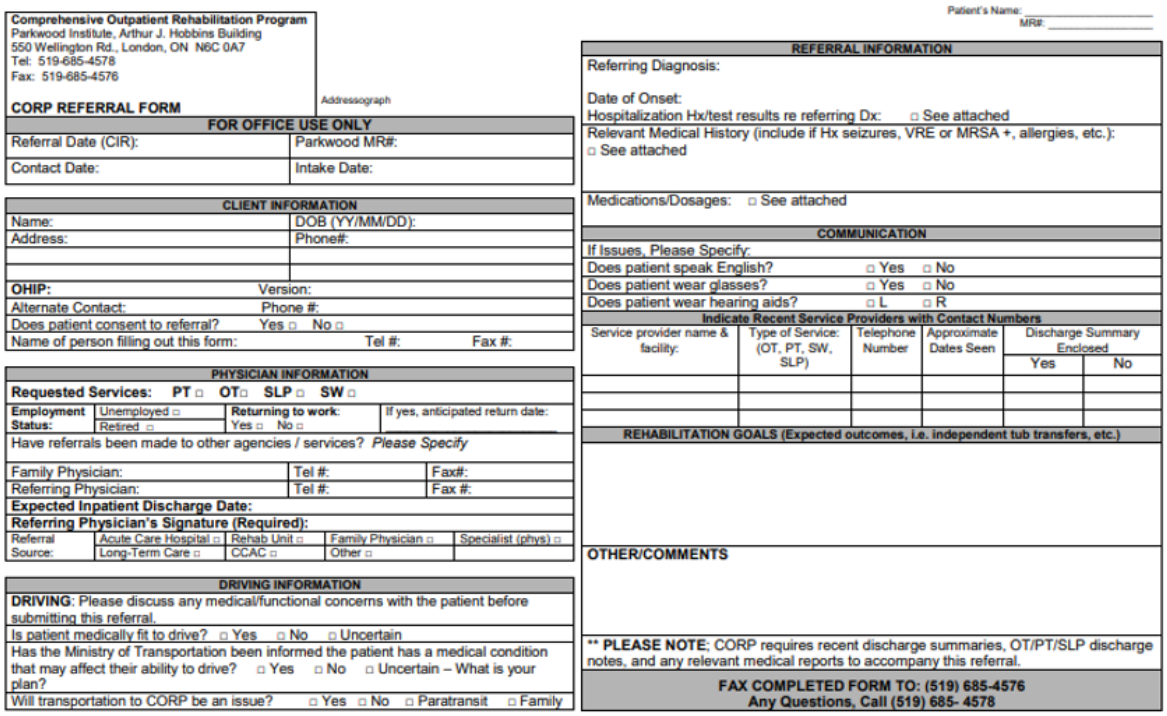
Relevant Medical/Psychiatric History (MRSA, Alzheimer's, Parkinson's, Dementia...) Attach Medication List if available:
Reaction to Medication ☐Y ☐N: Latex or Environmental Reaction ☐Y ☐N:
If yes please describe:
Is there a history of: ☐ Substance use ☐ Criminal offences or charges
please describe:

Referral Information:
Date of referral : (yy/mm/dd) | **Referral Source:** (Name of Person filling out the form - indicate agency if applicable)
Currently involved with SW LHIN?: ☐Y ☐N **Please Specify and Indicate Name Contact Number(s):**
Other agencies/services? (i.e., adult day programs, privately paid therapies, transportation services...):

Email Address: communitystrokerehab@sjhc.london.on.ca

St Joseph's Health Care London | Grey Bruce Health Services | Stroke Network

Figure 6. CSRT referral form (adopted from [32]).



Comprehensive Outpatient Rehabilitation Program
Parkwood Institute, Arthur J. Hobbins Building
550 Wellington Rd., London, ON N6C 0A7
Tel: 519-685-4578
Fax: 519-685-4576

CORP REFERRAL FORM

Addressograph

FOR OFFICE USE ONLY	
Referral Date (CIR):	Parkwood MR#:
Contact Date:	Intake Date:

CLIENT INFORMATION	
Name:	DOB (YY/MM/DD):
Address:	Phone#:
OHIP:	Version:
Alternate Contact:	Phone #:
Does patient consent to referral?	Yes □ No □
Name of person filling out this form:	Tel #: Fax #:

PHYSICIAN INFORMATION

Requested Services: **PT** □ **OT**□ **SLP** □ **SW** □

Employment Status:	Unemployed □ / Retired □	**Returning to work:** Yes □ No □	If yes, anticipated return date:

Have referrals been made to other agencies / services? *Please Specify*

Family Physician:	Tel #:	Fax#:
Referring Physician:	Tel #:	Fax #:

Expected Inpatient Discharge Date:
Referring Physician's Signature (Required):

Referral Source:	Acute Care Hospital □	Rehab Unit □	Family Physician □	Specialist (phys) □
	Long-Term Care □	CCAC □	Other □	

DRIVING INFORMATION

DRIVING: Please discuss any medical/functional concerns with the patient before submitting this referral.
Is patient medically fit to drive? □ Yes □ No □ Uncertain
Has the Ministry of Transportation been informed the patient has a medical condition that may affect their ability to drive? □ Yes □ No □ Uncertain – What is your plan?
Will transportation to CORP be an issue? □ Yes □ No □ Paratransit □ Family

Patient's Name: ____________
MR#: ____________

REFERRAL INFORMATION

Referring Diagnosis:

Date of Onset:
Hospitalization Hx/test results re referring Dx: □ See attached
Relevant Medical History (include if Hx seizures, VRE or MRSA +, allergies, etc.):
□ See attached

Medications/Dosages: □ See attached

COMMUNICATION

If Issues, Please Specify:
Does patient speak English? □ Yes □ No
Does patient wear glasses? □ Yes □ No
Does patient wear hearing aids? □ L □ R

Indicate Recent Service Providers with Contact Numbers

Service provider name & facility:	Type of Service: (OT, PT, SW, SLP)	Telephone Number	Approximate Dates Seen	Discharge Summary Enclosed	
				Yes	No

REHABILITATION GOALS (Expected outcomes, i.e. independent tub transfers, etc.)

OTHER/COMMENTS

** **PLEASE NOTE**; CORP requires recent discharge summaries, OT/PT/SLP discharge notes, and any relevant medical reports to accompany this referral.

FAX COMPLETED FORM TO: (519) 685-4576
Any Questions, Call (519) 685- 4578

Figure 7. CORP referral form (adopted from [33]).

1.4 Thesis Objective

This thesis seeks to explore if the current ad hoc clinical decision-making process at Parkwood Institute, an example of an ideal Canadian stroke outpatient rehabilitation system, can be modelled, and to explore if this decision-making process leads to fundamental differences between the groups referred to home or hospital-based rehabilitation.

Objective: To determine clinical and demographic factors that are associated with a referral to receive stroke outpatient rehabilitation services from CORP or CSRT.

To answer this question, a prognostic model will be developed from a retrospective cohort of patients who received inpatient rehabilitation at Parkwood Institute, and then were referred to and received outpatient services from CORP or

CSRT, to determine what clinical and non-clinical characteristics of a stroke survivor are associated with a referral to either.

Chapter 2: Literature Review

The following chapter will provide a brief review of the published research on stroke outpatient rehabilitation, in relation to program efficacy, cost comparisons for home-based and hospital-based programs, barriers in the transition from inpatient or acute care to outpatient rehabilitation and referral trends. International perspectives on stroke outpatient rehabilitation will be examined.

2.1 Program efficacy, home versus hospital-based stroke outpatient rehabilitation

Traditionally outpatient services have been solely centre/hospital-based. The introduction of home-based stroke outpatient rehabilitation has been a novel occurrence for several countries across the world in the past two decades. As such comparisons of patient benefits between the two outpatient systems have been conducted across different rehabilitation systems in the world.

The study design that has been considered the "gold standard" in evaluating the effects of two or more interventions on patient important outcomes are randomized controlled trials (RCTs).[34] Systematic reviews and meta-analyses of RCTs can be used to see how evidence on a topic can be pooled and summarized even further.[35]

Thus, to evaluate program efficacy of home-based versus hospital-based outpatient rehabilitation, RCTs and systematic reviews on the topic were considered. There are currently two systematic reviews on home-based versus hospital-based stroke outpatient rehabilitation; evaluating seven and 11 RCTs respectively.[36,37] Five additional RCTs were found not captured in these reviews.[38-42] A total of 20 unique RCTs were thus found on the topic.[38-57] The countries in which these RCTs were conducted in are seen in Figure 8.

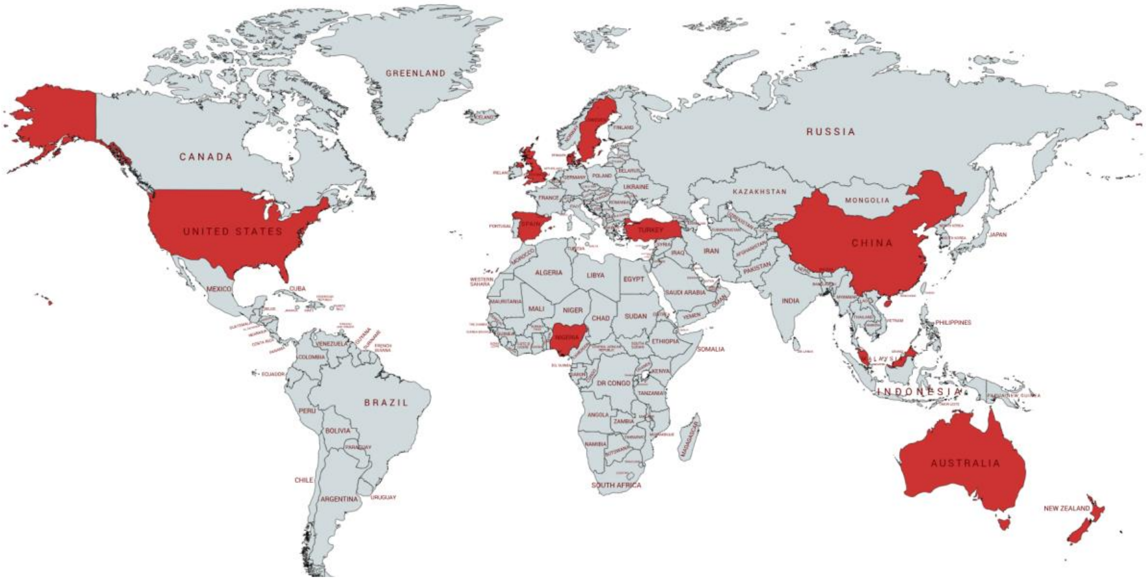


Figure 8. Different countries (highlighted in red) that have published research evaluating home-based versus hospital-based stroke outpatient rehabilitation programs on patient important outcomes.

Home-based outpatient rehabilitation was defined in these studies as receiving multidisciplinary, domiciliary care, provided in the patient's home, with therapy visits from an occupational therapist or physiotherapist. In two studies, home-based outpatient rehabilitation was provided through tele-rehabilitation, where stroke survivors received therapy through videoconferences or instructional videos.[39,41] While conventional care or hospital-based outpatient rehabilitation were typically weekly outpatient visits to a rehabilitation hospital, day hospital or a stroke clinic, patients also received multidisciplinary care at these centres, commonly from physiotherapists or occupational therapists. All patients in these trials received inpatient rehabilitation prior to starting outpatient rehabilitation, but the length of stay during inpatient rehabilitation varied from two weeks to two months. Patients were in both the acute (less than 1 month after stroke onset) and chronic (greater than 6 months after stroke onset) phases of recovery. Sample sizes ranged from 20 to 421 participants, and control and interventions groups were for the most part comparable in size. Intervention durations ranged from 3 weeks to 6 months, and therapy intensities ranged from 2.5 hours to 9 hours of therapy a week and were also comparable between groups.

A plethora of outcomes were examined for between-group differences for home-based and hospital-based outpatient rehabilitation. Measures assessed the following outcomes: functional independence and activities of daily living; overall disability; mental health; cognitive impairments; neglect; communication and language skills; upper and lower extremity function; balance; ambulation; social reintegration; service satisfaction; quality of life; hospital readmissions and caregiver burden. A detailed list of all these outcomes and their between-group effects can be seen in tables 1-4.

Table 1. Results of RCTs evaluating between groups differences for home-based and hospital-based stroke outpatient rehabilitation on outcome measures of functional independence and activities of daily living, and overall disability.

Outcome Measures	RCT (ref First author's last name and year of publication)	Between groups differences
Functional Independence and Activities of Daily Living		
Functional Independence Measure	[49]Bjorkdahl 2006 [38]Aydin 2016	- -
Barthel Index	[57]Young 1992 [43]Gladman 1993 [50]Duncan 1998 [47]Baskett 1999 [48]Andersen 2000 [51]Gilbertson 2000 [56]Wolfe 2000 [55]Roderick 2001 [53]Lincoln 2004 [41]Redzuan 2012 [39]Chen 2017	- - - - - +hospital - - - - -
Katz Index	[46]Widen Holmqvist 1998	-
Index of Extended Activities of Daily Living	[43]Gladman 1993 [48]Andersen 2000 [53]Lincoln 2004	- - -
Frenchay Activities Index	[46]Widen Holmqvist 1998 [48]Andersen 2000 [54]Roderick 2001	- - -
Instrumental Activity Measure	[49]Bjorkdahl 2006	-
Lawton Instrumental Activities of Daily Living	[50]Duncan 1998	-
Nottingham Extended Activities of Daily Living	[52]Gilbertson 2000	+home
Canadian Occupational Performance Measure	[52]Gilbertson 2000	+home
Overall Disability Level		
Modified Rankin Scale	[39]Chen 2017	-
National Institute of Health Stroke Scale	[49]Bjorkdahl 2006	-
Barrow Neurological Institute Screening	[49]Bjorkdahl 2006	-
London Handicap Scale	[52]Gilbertson 2000	+home

Note:

+hospital corresponds to a statistically significant difference between groups in favour of the hospital-based outpatient group at α=0.05, post-intervention

+home corresponds to a statistically significant difference between groups in favour of the home-based outpatient group at α=0.05, post-intervention

- corresponds to no statistically significant difference between groups at α=0.05, post-intervention

Table 2. Results of RCTs evaluating between groups differences for home-based and hospital-based stroke outpatient rehab on outcome measures of mental health, cognitive impairments, neglect, and language impairment.

Outcome Measures	RCT (ref First author's last name and year of publication)	Between groups differences
Mental Health		
Hospital Anxiety and Depression Scale	[47]Baskett 1999 [56]Wolfe 2000	- -
Dartmouth Cooperative Functional Assessment	[52]Gilbertson 2000	+home
Philadelphia Geriatric Center Morale Scale	[54]Roderick 2001	-
Cognitive Impairments		
Abbreviated Mental Test Score	[43]Gladman 1993 [54]Roderick 2001	- -
Mini Mental State Examination	[56]Wolfe 2000	-
Neglect		
Albert's Test	[56]Wolfe 2000	-
Language impairment		
Frenchay Aphasia Screening Test	[56]Wolfe 2000	-

Note:

+hospital corresponds to a statistically significant difference between groups in favour of the hospital-based outpatient group at α=0.05, post-intervention

+home corresponds to a statistically significant difference between groups in favour of the home-based outpatient group at α=0.05, post-intervention

- corresponds to no statistically significant difference between groups at =0.05, post-intervention

Table 3. Results of RCTs evaluating between groups differences for home-based and hospital-based stroke outpatient rehab on outcome measures of upper and lower extremity function, balance, and ambulation.

Outcome Measures	RCT ([ref] First author's last name and year of publication)	Between groups differences
Upper Extremity Function		
9-hole peg test	[47]Baskett 1999	-
Frenchay Arm Test	[47]Baskett 1999	-
Grip Strength	[47]Baskett 1999	-
Fugl Meyer Motor Assessment	[50]Duncan 1998	+[home]
Medical Outcomes Study-36 Health Status Measurement	[50]Duncan 1998	+[home]
Jebsen Taylor Test of Hand Function	[50]Duncan 1998	-
Motoricity Index	[56]Wolfe 2000	-
Root Mean Square of Extensor Carpi Radialis Longus	[39]Chen 2017	-
Shoulder Subluxation	[41]Redzuan 2012	-
Modified Ashworth Scale	[47]Baskett 1999	-
Modified Motor Assessment Scale	[42]Olaleye 2014	-
Lower Extremity Function		
Fugl Meyer Motor Assessment	[50]Duncan 1998	+[home]
Medical Outcomes Study-36 Health Status Measurement	[50]Duncan 1998	-
Rivermead Mobility Index	[54]Roderick 2000 [56]Wolfe 2000	- -
Motor Club Assessment	[57]Young 1992	+[home]
Root Mean Square of Tibialis Anterior	[39]Chen 2017	-
Balance		
Berg Balance Scale	[50]Duncan 1998 [39]Chen 2017	+[home] -
Activities-specific Confidence Balance Scale	[40]Lord 2008	-
Short Form-Postural Assessment Scale for Stroke	[42]Olaleye 2014	-
Ambulation and Gait Speed		
10 Metre Timed Walk Test	[50]Duncan 1998 [47]Baskett 1999 [40]Lord 2008	+[home] - -
30 Metre Timed Walk Test	[49]Bjorkdahl 2006	-
5 Minute Walk Test	[56]Wolfe 2000	-
6 Minute Walk Test	[50]Duncan 1998 [40]Lord 2008 [42]Olaleye 2014	+[home] - -

Note:

+[hospital] corresponds to a statistically significant difference between groups difference in favour of the hospital-based outpatient group at α=0.05, post-intervention

+[home] corresponds to a statistically significant difference between groups in favour of the home-based outpatient group at α=0.05, post-intervention

- corresponds to no statistically significant difference between groups at =0.05, post-intervention

Table 4. Results of RCTs evaluating between groups differences for home-based and hospital-based stroke outpatient rehab on outcome measures of social integration, service satisfaction, quality of life, hospital readmissions, and caregiver burden.

Outcome Measures	RCT ([ref] First author's last name and year of publication)	Between groups differences
Social Integration and Community Participation		
Subjective Index of Physical and Social Outcome	[40]Lord 2008	-
Brief Assessment of Social Engagement	[43]Gladman 1993	-
Reintegration to Normal Living Index	[42]Olaleye 2014	-
Satisfaction with Provision of Outpatient Services		
Patient Satisfaction	[53]Lincoln 2004	$+^{home}$
Caregiver Satisfaction	[53]Lincoln 2004	$+^{home}$
Quality of Life		
Nottingham Health Profile	[45]Rodgers 1997 [43]Gladman 1993 [56]Wolfe 2000 [57]Young 1992	- - - $+^{home}$
Nottingham Life Satisfaction Index	[43]Gladman 1993	-
Sickness Impact Profile	[46]Widen Holmqvist 1998	-
General Health Questionnaire	[57]Young 1992 [53]Lincoln 2004	- -
EuroQoL	[53]Lincoln 2004	-
Perceived Quality of Life	[54]Roderick 2001	-
Hospital Readmissions		
Readmission Rates	[48]Andersen 2000	-
Caregiver Burden		
Caregiver Strain Index	[39]Chen 2017 [41]Redzuan 2012 [53]Lincoln 2004 [56]Wolfe 2000	- - $+^{home}$ -
General Health Questionnaire	[47]Baskett 1999 [53]Lincoln 2004	- -

Note:
$+^{hospital}$ corresponds to a statistically significant difference between groups in favour of the hospital-based outpatient group at α=0.05, post-intervention
$+^{home}$ corresponds to a statistically significant difference between groups in favour of the home-based outpatient group at α=0.05, post-intervention
- corresponds to no statistically significant difference between groups at =0.05, post-intervention

In short, for the majority of study outcomes, improvements were comparable between home-based and hospital-based outpatient stroke rehabilitation groups. However, some between group differences were significantly in favour of home-based rehabilitation. These included: two measures of functional independence and activities of daily living;[53] a measure of disability;[53] emotional control;[53] two measures of upper and lower extremity function respectively;[51,58] the Berg balance scale;[51] two measures of ambulation;[51] patient and caregiver satisfaction;[54] a measure of quality of life;[58] and caregiver strain.[54] However, these results were found only in four of the 20 RCTs. There was also a significant between-group effect in one RCT in favour of hospital-based outpatient rehabilitation on the Barthel Index, a measure of functional independence and activities of daily living.[52]

The systematic review by Hiller et al.,[37] pooled study findings for the Barthel Index, a measure of functional independence and found marginally significant effects of improvement favouring the home-based group at 6-8 weeks post intervention (mean difference = 1.00 [95% CI: 0.12 to 1.88], df=1, p=0.03), and at 6-month follow-up (mean difference = 1.04 [95% CI: 0.05 to 2.04], df=4, p=0.04). The systematic review by Britton et al.,[36] found no differences between groups.

In conclusion, some studies suggest a minor benefit of home-based outpatient stroke rehabilitation, but the majority of studies and outcomes point to these two groups being very comparable in terms of improvement on patient important outcomes.

2.2 Cost comparisons of outpatient rehabilitation

Another area to consider is the differing financial costs of home-based and hospital-based outpatient stroke rehabilitation. Cost comparison studies of the provision of home-based and hospital-based outpatient stroke rehabilitation were conducted primarily in Europe, and monetary amounts are reported in Pounds (£) and Euros (€). An older systematic review by Britton et al.,[36] reported cost-minimization analyses from individual studies and found home-based rehabilitation was more expensive in one study (home-based: £408, hospital-based: £320), cheaper in two studies (home-based: £385 and

£6800, hospital-based: £620 and £7432, respectively), and no different in one study (home-based: £7155, hospital-based: £7480).

An RCT by Roderick et al.,[54] performed cost comparisons of home-based and day-hospital outpatient stroke rehabilitation, and found the two groups had similar mean costs for rehabilitation (domiciliary: £1170 ± 876, day hospital: £1146 ± 802), health services (domiciliary: £1965 ± 1818, day hospital: £2057 ± 2357), and social services (domiciliary: £1965 ± 1818, day hospital: £2057 ± 2357) per patient after 17 visits. An RCT by Bjorkdahl et al.,[49] looked at patients discharged from inpatient rehabilitation who were randomized to receive either rehabilitation at home or outpatient visits in a day clinic. This study found that when factoring in all the different costs of home-based outpatient rehabilitation (i.e. occupational therapist/physiotherapist salary, travel time, gas mileage, and overhead costs), this was still less than half the mean cost of the services provided by the day clinic (home group: €1830, day clinic: €4410) for the length of the intervention (9 hours per week, for three weeks).

In conclusion, though these studies differ in therapy intensities, the way rehabilitation was provided, and the parameters used to estimate costs, home-based rehabilitation is either as cost-effective as hospital-based programs or cheaper in some cases.

2.3 Barriers to receiving outpatient rehabilitation

The transition from inpatient rehabilitation to outpatient rehabilitation can be complicated by many factors at both a patient and systems level. A report of outpatient rehabilitation usage in the United States of 20 states in 2013, and four states in 2015 found that only a third of stroke survivors use outpatient services. Common barriers reported by patients included a lack of access and transportation to outpatient facilities, not understanding the benefits of outpatient rehabilitation for stroke survivors, no education about alternative outpatient programs outside of a hospital (i.e. home-based care, tele-rehabilitation), high out of pocket costs, and insufficient health insurance coverage.[58]

A narrative synthesis by Hempler et al.[59] examined the provision of post-stroke care after medical rehabilitation in Germany, a stroke system with excellent acute care and medical rehabilitation, but with inadequate outpatient follow-up care. They found that around half of the treatment plans for outpatient rehabilitation for patients who received inpatient rehabilitation were seen to completion. Therapists and physicians attributed this shortage of outpatient care to a lack of multidisciplinary cooperation across different medical disciplines, and the transfer of information about available post-medical rehabilitation services to patients and their caregivers. Outpatient therapists reported that caregiver burden is so high for some caregivers that occupational therapists often find themselves providing emotional support to both the patient and their caregiver. They emphasized the important but undervalued role caregivers have in a patient's care. For instance, caregivers simply providing transportation for patients to and from the hospital saves the German health care system a large amount of money. Germany is implementing services to improve follow-up care; these include: an information hub where patients and their caregivers can inquire about reintegration to normal living or return to work; specialized stroke nurse home visits that include scheduling outpatient appointments; stroke prevention strategies to prevent recurrence. Additionally assistance in the management of psychosocial deficits, and the use of case management strategies through privatised insurance companies, where patients are monitored, have supports available and can book appointments with therapists and physicians through a phone call with a social worker.

A qualitative study by Rattray et al.[60] investigated the barriers in the transition from inpatient to outpatient care in the United States from the perspective of healthcare providers. They conducted interviews with nine inpatient healthcare providers and 12 outpatient healthcare providers. They concluded that communication between outpatient and inpatient healthcare providers in patient transfers was lacking. Medication and treatment plans were often inconsistent, concise or complete. In these plans, there was often no rationale behind the reason for discharge, and poor attention to detail in completing the plans resulting in a lack of trustworthiness and misinterpretation of information. Outpatient healthcare providers advocate for the implementation of a reliable, standardized discharge documentation that would entail a clear assessment of symptoms, stroke etiology, severity of the stroke and a follow-up plan. There is often miscommunication between the location of records in both inpatient and outpatient facilities, and a lack of consistency between forms filled out by various clinical staff when completing discharge plans. Finally, the use of multiple modes of communication would be advantageous in the patient hand-off. Currently, communication is primarily done through the electronic health record; this information can be vague, misinterpreted and ambiguous for outpatient staff. The transition of care could benefit from a phone-call, email or face to face meeting between the primary stroke care physicians from both the inpatient and outpatient facility to build a rapport and familiarity for different patient cases.[60]

2.4 Referral trends

Unfortunately, there exists no published literature on referral patterns to outpatient rehabilitation from a Canadian perspective. There is however literature about factors that influence referral and discharge destinations in the American stroke system. The stroke system in the United States is broadly similar but has important differences from the system used in Ontario (Figure 9). Stroke is initially managed in acute care, but there are two levels of institutional care for inpatients: inpatient rehabilitation facilities and skilled nursing facilities. As well outpatient services exist in the traditional hospital model - outpatient rehabilitation, and a home-based service - home health services. Inpatient rehabilitation facilities are considered the most intensive level of post acute-care, followed by skilled nursing facilities, then home health services and finally outpatient rehabilitation.[61]

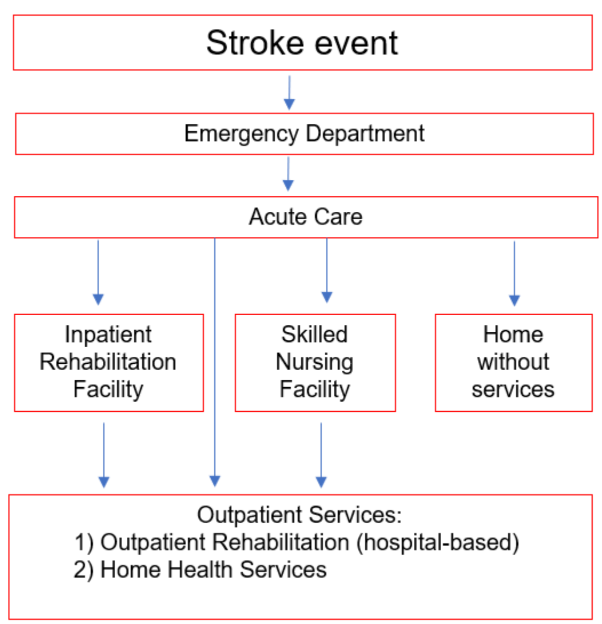


Figure 9. Typical care pathway trajectories for a stroke survivor in the United States.

With the annual incidence of strokes in the United States being 12 times larger than that of Canada's (approximately 759,000 cases), lessons can be learned from this system to apply in Canada.[62] Studies examining the association between patient characteristics and discharge destinations reported their results as odds ratios or rate ratios. Odds ratios are the odds that a binary outcome (i.e. disease present versus disease absent) will occur given a specific exposure variable, compared to the odds of the outcome occurring in the absence of that exposure.[63] Odds ratios are commonly the output of multivariable logistic regression models.

Literature exists on factors that influence referral to inpatient rehabilitation facilities, skilled nursing facilities, and discharge to home with no services.[61,62,65] Looking specifically at referral patterns to outpatient services, Freburger et al.[62] in a large cohort study of inpatients (N=187,1998), using multivariable logistic regression models found that individuals who were African-American, Hispanic, female, older, on Medicare, and with low median household incomes, had attended an acute care hospital with a high volume of stroke admissions, and lived in a county with a high number of employed physiotherapists and occupational therapists were more likely to receive home health care services (Table 5).

Additionally, a study by Chan et al.[66] looked at factors associated with a discharge to an outpatient rehabilitation facility or to a home health service for stroke survivors admitted to the Northern California Kaiser Permanente Health System. In a Poisson regression model, they found that individuals who were younger, male, Asian, African-American, Hispanic, lived in an urban area, lived in an area with a high median household income, had an ischemic stroke, and a longer acute care length of stay were associated with a higher number of outpatient rehabilitation visits (Table 6). A multivariable logistic regression model found that individuals who were older, female, Asian, African-American, Hispanic, lived in an urban residence, had an ischemic stroke, and had a longer acute length of stay were more likely to enroll in home health services (Table 5).

Table 5. Factors significantly associated with an admission to home health services.

Covariate [ref]	Odds Ratio	95% Confidence Interval	p-value
Older age [62, 66]	1.51 1.04	1.48 to 1.54 1.03 to 1.04	p<0.001 p<0.0001
Female [62, 66]	1.33 1.23	1.29 to 1.38 1.14 to 1.33	p<0.001 p<0.0001
Asian [66]	1.30	1.13 to 1.50	p<0.0001
African-American [62,66]	1.56 1.36	1.47 to 1.65 1.19 to 1.55	p<0.001 p<0.0001
Hispanic [62, 66]	1.14 1.17	1.07 to 1.21 1.00 to 1.36	p<0.001 p<0.0001
Received Medicare health insurance [62]	1.41	1.34 to 1.49	p<0.001
Low median household income [62]	1.10	1.04 to 1.17	p=0.002
High stroke admission acute care hospital [62]	1.05	1.02 to 1.08	p=0.003
Lived in an urban area [66]	0.59	0.48 to 0.73	p<0.0001
Area with a high number of physiotherapists and occupational therapists employed [62]	1.02	1.00 to 1.03	p=0.006
Had an ischemic stroke [66]	0.61	0.54 to 0.69	p<0.0001
Longer acute care length of stay [66]	1.08	1.07 to 1.09	p<0.0001

Table 6. Factors significantly associated with increasing healthcare utilization of outpatient rehabilitation.

Covariate [ref]	Rate Ratio	95% Confidence Interval	p-value
Younger age [66]	0.98	0.98 to 0.98	p<0.0001
Male [66]	0.83	0.82 to 0.84	p<0.0001
Asian [66]	1.06	1.05 to 1.08	p<0.0001
African-American [66]	1.05	1.03 to 1.06	p<0.0001
Hispanic [66]	1.01	0.99 to 1.02	p<0.0001
Lived in an urban area [66]	0.97	0.95 to 0.99	p=0.0023
High median household income [66]	0.87	0.86 to 0.88	p<0.0001
Had an ischemic stroke [66]	0.736	0.727 to 0.744	p<0.0001
Longer acute care length of stay [66]	1.066	1.065 to 1.067	p<0.0001

Several patient and clinical characteristics influence rehabilitation services at the outpatient level in the United States. These included a stroke survivor's age, gender, ethnicity, type of stroke, socioeconomic status, if they had health insurance, if they lived in urban or rural area and their length of acute care stay. Additionally, some hospital-level variables were found to be factors associated with rehabilitation service provision including: the number of stroke admissions an acute hospital receives, and the employment density of rehabilitation clinicians at a hospital. These referral trends point to a pattern that certain covariates can influence if a patient receives outpatient rehabilitation services.

2.5 Knowledge gap

With the advent of ideal outpatient rehabilitation models in Ontario having both a home-based and hospital-based component, it is important to see if trends in referral patterns similar to the American stroke system exist. Though research has shown that home-based and hospital-based outpatient rehabilitation programs are comparable on patient outcomes, the costs and barriers to receiving each outpatient service can be different. Thus, this thesis seeks to develop a prognostic model of a retrospective cohort of patients who received inpatient rehabilitation at Parkwood Institute, who received outpatient services from CORP or CSRT to determine what clinical and non-clinical characteristics of a stroke survivor are associated with referrals to each. Ideally to learn if certain patient characteristics are more predictive of receiving one outpatient service over the other.

Chapter 3: Methods

3.1 Study design

This was a prognostic prediction model development study for admission to hospital-based (CORP) or home-based (CSRT) outpatient rehabilitation. The model was created from a retrospective cohort of patients who received inpatient rehabilitation at Parkwood Institute and then were referred to and received outpatient services from CORP or CSRT. This study followed the guidelines set out by the Transparent Reporting of a multivariable prediction model for Individual Prognosis Or Diagnosis (TRIPOD) statement for developing a multivariable prediction model.[67]

3.2 Study dataset characteristics

3.2.1 Data collection and collation

The study cohort were 721 stroke survivors who attended inpatient rehabilitation at Parkwood Institute in London, Ontario between January 1, 2009 and March 1, 2016. This sample represents all available patients who met our inclusion criteria. To be eligible for inclusion in the cohort, patients had to have attended inpatient rehabilitation during the above time period, lived within the Southwest LHIN, and after completing inpatient rehabilitation were referred and received at least four therapy visits from either CORP or CSRT. Four therapy visits were used as a criterion because patients who tend to have greater than four visits tend to stay longer in the program (average of 30 visits), while those with less than four visits tend to use outpatient services for assessments and not prolonged use. Acute care and inpatient rehabilitation data for Ontario stroke survivors are kept in a province-wide administrative dataset called the National Rehabilitation Reporting System managed by the Canadian Institute for Health Information (CIHI).

Inpatient rehabilitation data for the study cohort was accessed electronically through the National Rehabilitation Reporting System. Variables that were collected included a patient's: inpatient hospital identification number, age, gender, date of stroke onset, number of comorbidities, vocational status, postal code, living setting, living arrangements, rehabilitation client group status (RCG), rehabilitation patient group status (RPG) (RCG and RPG explained in detail in section 3.2.3), inpatient admission and discharge dates, functional independence measure (FIM) admission and discharge scores, CIHI data elements of activities of daily living and cognitive functioning admission and discharge scores (these include questionnaires addressing: presence of pain, written communication, auditory communication, reading comprehension, financial management, orientation, and general health status). Outpatient rehabilitation data for patients who received CSRT were provided electronically through CSRT administrative services, while outpatient rehabilitation data for CORP were retrieved through retrospective chart reviews at Parkwood Institute. Outpatient rehabilitation data included: a patient's inpatient hospital identification number, the outpatient program a stroke survivor attended, and admission and discharge dates. Inpatient and outpatient data were then collated into one dataset by matching corresponding inpatient hospital identification numbers.

3.2.2 Descriptions of rehabilitation programs

Inpatient rehabilitation was provided at Parkwood Institute, in London Ontario, a designated stroke center for inpatient services in the Southwest LHIN.[23] Patients received multidisciplinary treatment from physiatrists, physiotherapists, occupational therapists, speech language pathologists, recreational therapists, dietitians, nurses and social workers. Patients were discharged from inpatient rehabilitation after completing their length of stay and with approval of the clinicians treating the patient. Discharge destinations for this study cohort were either CORP or CSRT.

CORP is a hospital-based outpatient rehabilitation program provided at Parkwood Institute. Patients attending CORP receive rehabilitation from a multidisciplinary team of physiotherapists, occupational therapists, speech language pathologists and social workers.

CSRT is a home-based outpatient rehabilitation program, provided in patients' homes throughout the Southwest LHIN. Patients receive individualised therapy from occupational therapists, physiotherapists, physiotherapist aides, speech language pathologists, social workers, registered nurses and recreational therapists.

3.2.3 Study variables in model development dataset

Below is a detailed list of the covariates and outcome variable used in deriving the prediction model. For variables measured at both admission to and discharge from inpatient rehabilitation, discharge scores were used as potential covariates in the model, as these are the scores the rehabilitation team considers during discharge destination planning.

<u>Covariates</u>

Demographics

Age: The age of the patient at admission to an outpatient service. This is a continuous variable, where the unit of measurement is years.

Gender: The biological sex of the patient, restricted to self-identification as a male or female. This is a binary variable that is coded as: 0=Male, 1=Female.

Number of comorbidities: Comorbidities were defined according to the International Statistical Classification of Diseases and Related Health Problems, version 10 (ICD-10).[68] This variable is the total number of comorbidities that a patient has at admission to an inpatient stroke unit. This is a continuous, count variable.

Vocational status: The vocational status a patient had prior to admission to their stroke. This is a categorical variable, coded as: 0=Employed, 1=Unemployed, 2=Student, 3=Retired.

Living setting: Where the patient was living prior to their outpatient admission. This is a categorical variable, coded as:1= Long term care, 2=Acute care, 3=Home.

Presence of a caregiver: This variable indicates if the patient had a formal or informal caregiver who lived with them prior to their outpatient admission. This is a binary variable coded as: 1=Yes, 0=No.

Rural vs urban status: This variable was calculated using patients' postal codes. Postal codes were individually entered into an online tool provided by the Ontario Medical Association that converts postal codes to their corresponding Rurality Index of Ontario score.[69] This tool provides a score on a scale of 0 to 100; scores ≥40 are indicative of a rural residence, while scores <40 are indicative of an urban residence. This is a binary variable coded as: 1=Rural, 0=Urban.

Distance to travel to Parkwood Institute: A variable that measures how far patients' residences are from Parkwood Institute, the site where CORP services are provided. This variable was calculated using patients' postal codes and google maps to get approximate estimates of the distance traveled in kilometers to reach Parkwood Institute from a patient's home. This is a continuous variable, where the unit of measurement is kilometers.

Clinical measures

RCG: The rehabilitation client groups (RCG) that specify the type of stroke diagnosis a patient was admitted to inpatient rehabilitation for. This is a categorical variable, coded as: 0=Right hemisphere stroke, 1=Left hemisphere stroke, 2=Bilateral stroke, 3= No paresis stroke, 4=Other stroke.

RPG: A patient's rehabilitation patient group (RPG) is used as a proxy for a patient's stroke severity when entering inpatient rehabilitation. An Ontario-wide measure, the RPG is calculated using a patients' age, and the motor and cognitive sub-scores of a patient's admission FIM score.[70] There are seven groups corresponding to: mild strokes (RPG: 1150,1160); moderate strokes (RPG: 1120-1140); and severe strokes (RPG: 1100,1110). This is a categorical variable, coded as: 0=mild, 1=moderate, 2=severe.

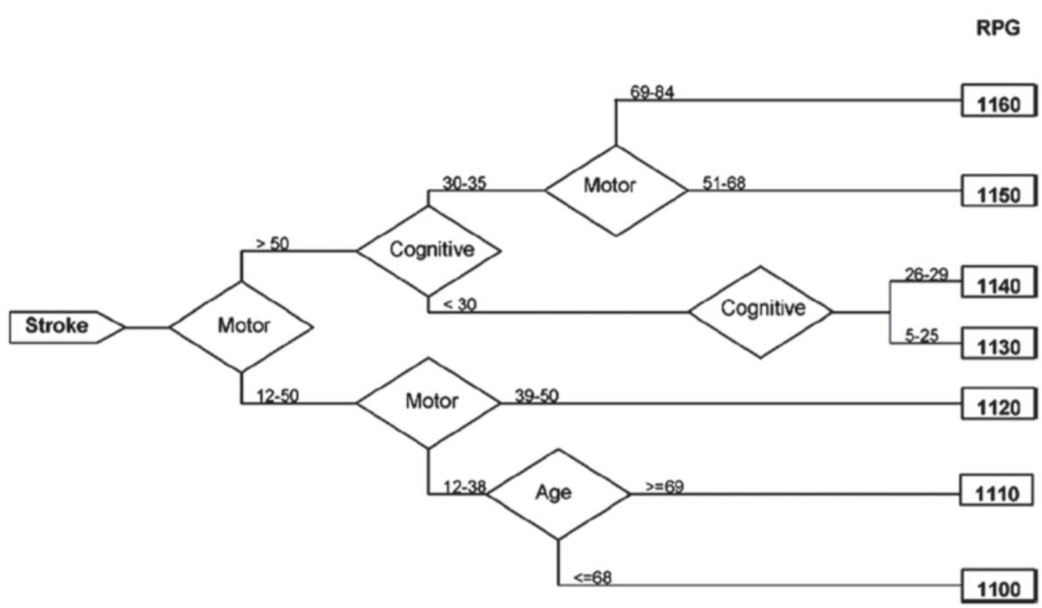


Figure 10. The RPG algorithm for classifying stroke patients (adopted from [70]).

Inpatient FIM discharge total score: A patient's discharge functional independence measure (FIM) score from stroke inpatient rehabilitation is the last functional assessment a patient has prior to their outpatient rehabilitation admission. The FIM is an 18-item outcome measure composed of both cognitive (5-items) and motor (13-items) subscales. Each item assesses the level of assistance required to complete an activity of daily living on a 7-point scale. The summation of all the item scores ranges from 18 to 126, with higher scores being indicative of greater functional independence.[71] This is a continuous variable.

Inpatient FIM discharge motor sub-score: The motor sub-score (13-items) of a patient's inpatient discharge FIM score. This is a continuous variable.

Inpatient FIM discharge cognitive sub-score: The cognitive sub-score (5-items) of a patient's inpatient discharge FIM score. This is a continuous variable.

Inpatient FIM total gain: This score is the subtraction of a patient's inpatient admission and discharge FIM total scores, to calculate the gain in total FIM scores a patient made during inpatient rehabilitation. This is a continuous variable.

Inpatient FIM motor sub-score gain: This score is the subtraction of a patient's inpatient admission and discharge FIM motor sub-scores, to calculate the gain in FIM motor sub-scores a patient made during inpatient rehabilitation. This is a continuous variable.

Inpatient FIM cognitive sub-score gain: This score is the subtraction of a patient's inpatient admission and discharge FIM cognitive sub-scores, to calculate the gain in FIM cognitive sub-scores a patient made during inpatient rehabilitation. This is a continuous variable.

CIHI data elements, presence of pain discharge score: One of the CIHI data elements looking at if the patient reports pain at discharge from inpatient rehabilitation. This is a categorical variable, coded as: 0=No, 1=Yes, 2=Client unable to answer.

CIHI data elements, verbal or non-verbal communication discharge score: One of the CIHI data elements looking at if the patient is able to effectively communicate verbally or non-verbally at discharge from inpatient rehabilitation. This is a categorical variable, coded as: 0=Independent, 1=Supervision, 2=Assistance, 3=Dependent, 4=Non-functional, 5=Not able to test.

CIHI data elements, written communication discharge score: One of the CIHI data elements looking at a patient's written communication skills at discharge from inpatient rehabilitation. This is a categorical variable, coded as: 0=Independent, 1=Supervision, 2=Assistance, 3=Dependent, 4=Non-functional, 5=Not able to test.

CIHI data elements, auditory or non-auditory comprehension discharge score: One of the CIHI data elements looking at a patient's ability to comprehend auditory and non-auditory (i.e. sign language) cues, at discharge from inpatient rehabilitation. This is a categorical variable, coded as: 0=Independent, 1=Supervision, 2=Assistance, 3=Dependent, 4=Non-functional, 5=Not able to test.

CIHI data elements, reading comprehension discharge score: One of the CIHI data elements looking at a patient's reading comprehension ability at discharge from inpatient rehabilitation. This is a categorical variable, coded as: 0=Independent, 1=Supervision, 2=Assistance, 3=Dependent, 4=Non-functional, 5=Not able to test.

CIHI data elements, financial management discharge score: One of the CIHI data elements looking at a patient's ability to manage their personal finances at discharge from inpatient rehabilitation. This is a categorical variable, coded as: 0=Independent, 1=Supervision, 2=Assistance, 3=Dependent, 4=Non-functional, 5=Not able to test.

CIHI data elements, orientation discharge score: One of the CIHI data elements looking at a patient's ability to orient themselves in relation to time, place and self, at discharge from inpatient rehabilitation. This is a categorical variable, coded as: 0=Oriented to time, place, and self, 1=Oriented to one or two items, 2=Oriented to none of the items.

CIHI data elements, subjective general health status discharge score: One of the CIHI data elements looking at a patient's general health status at discharge from inpatient rehabilitation. This is a categorical variable, coded as: 0=Poor, 1=Fair, 2=Good, 3=Very good, 4=Excellent.

Inpatient length of stay: This variable measures a patient's inpatient length of stay, from their date of admission to their date of discharge. This is a continuous variable, where the units of measurement are days.

Outcome variable

Outpatient program: This variable is the outpatient program a patient received, either CSRT or CORP. Patients were referred to a service after completing their length of stay at inpatient rehabilitation, and once admitted to an outpatient program, received at least four therapy visits. This is a binary variable coded as: 0=CSRT, 1=CORP.

3.3 Data analysis

The methodology of this study follows the guidelines set out by the TRIPOD statement for developing a multivariable prognostic model.[67] The outcome to be predicted is admission to either CSRT or CORP for stroke outpatient rehabilitation. All analyses were conducted using the statistical programs: R version 3.5.0 or Stata version 13.

3.3.1 Missing values

Before conducting any analyses, the amount of missingness in our dataset was evaluated. No missingness was found in our outcome variable, but some was found in our covariates (Table 7). The degree of missingness from each of our covariates seemed to be missing at random, and the highest missingness for a single covariate (number of comorbidities) was 4% of the total dataset. Therefore, a complete case analysis was used, as this approach has negligible bias when missingness is independent of the outcome variable in relation to the covariates, and the number of observations missing is close to 5%.[72,73] A complete case analysis resulted in a reduced dataset of 671 individuals, compared to the original 721, 7% of individuals were excluded using this approach. This new cohort of 671 individuals was used for all proceeding analyses.

Table 7. Distribution of covariates with missing data in original dataset (n=721).

Covariate	**Missingness: n (%)**
Number of comorbidities	29 (4.0%)
Vocational status	6 (0.8%)
Presence of a caregiver	1 (0.1%)
Rural or Urban status	6 (0.8%)
Distance to Parkwood	4 (0.6%)
Gender	2 (0.3%)
Inpatient FIM discharge total score	4 (0.6%)

Inpatient FIM discharge motor score	4 (0.6%)
Inpatient FIM discharge cognitive score	4 (0.6%)
Inpatient FIM total gain	4 (0.6%)
Inpatient FIM motor gain	4 (0.6%)
Inpatient FIM cognitive gain	4 (0.6%)
CIHI data elements presence of pain	8 (1.1%)
CIHI data elements verbal communication	4 (0.6%)
CIHI data elements written communication	4 (0.6%)
CIHI data elements auditory communication	4 (0.6%)
CIHI data elements reading comprehension	4 (0.6%)
CIHI data elements financial management	4 (0.6%)
CIHI data elements orientation	4 (0.6%)
CIHI data elements general health status	8 (1.1%)

3.3.2 Descriptive statistics

Descriptive statistics were calculated for each of the covariates and the outcome variable. For continuous variables, means and standard deviations (SD) were calculated. For binary or categorical variables, frequencies and proportions were calculated.

3.3.3 Linearity assumption for continuous variables in a logistic regression model

Component residual plots were constructed for continuous variables to see if a linear relationship existed with the binary outcome variable, before constructing any multivariable logistic regression models. Component residual plots are a plot of the residuals of a covariate against the logit of the outcome variable; a covariate has a linear relationship with the outcome variable if a line of best fit and a locally weighted scatterplot smoothing (lowess) smooth line (i.e. line of the residuals) are linear and overlap.[74] Univariable logistic regression models were used to generate component residual plots for each covariate.

3.3.4 Model building and variable selection

Univariable logistic regression models were constructed for each of the covariates with the outcome variable. A selection criterion for variables was a significance level equal to or less than α=0.25.[75] Variables with a p-value greater than 0.25, were not considered for inclusion, unless they were deemed still clinically or practically relevant as a factor in patient referral. A correlation matrix was also calculated to detect any variables that might have strong collinearity with each other (a Pearson's correlation coefficient greater than 0.5) [76]. Colinear variables were excluded as well.

After variable selection through univariable associations, the remaining covariates were included as predictors in a multivariable logistic regression model. To reduce the number of covariates and create a more parsimonious model, an automated variable selection method (backward elimination) was employed. Backward elimination starts with a full regression model with all the covariates, and sequentially removes them until a prespecified stopping rule is met.[67] Backward elimination is a favourable automated variable selection method, as it considers all correlations between predictors in the modelling procedure.[67] The Akaike information criterion (AIC) was used as the stopping rule during backward elimination selection. The AIC is optimal in that it accounts for model fit while penalizing for the number of parameters being estimated and corresponds to using a conservative significance level of α=0.157.[67] Lower AIC values are indicative of better model fit.[77] Interaction terms were not considered, as there was no prior rationale for potential interactions between covariates, and interaction terms are seldom reported in prediction models.[67] Predictors were in favour of receiving CSRT if the odds ratio was less than 1, and to be in favour of receiving CORP if the odds ratio was greater than 1 (CSRT coded as 0, CORP coded as 1). Significance was set at α=0.05.

3.3.5 Apparent performance measures

Once a final model is created using backward elimination, the model can be evaluated on the same data from which it was developed. This is known as the model's apparent performance and can be calculated with the following measures.

Calibration is a measure that reflects the agreement between predictions from the model and observed outcomes. This is reported graphically with a calibration plot, with predicted outcome probabilities on the x-axis versus observed outcome frequencies on the y-axis. The units of measurement for the plot are tenths of the predicted and observed risks. The predicted probability range is compared to a line with a slope of 1 and intercept of 0. The amount of alignment between the predicted probability range and this line indicates the degree of agreement between predicted and observed outcomes.[67]

Discrimination: describes a prediction model's ability to differentiate between individuals who do or do not experience the outcome event. Discrimination can be estimated using the concordance index (c-index). The c-index describes the probability that for any randomly selected pair of individuals, one with and one without the outcome, the model assigns a higher probability to the individual with the outcome. The c-index is equal to the area under a receiver-operating characteristic curve for models with binary endpoints.[67] The c-index can range in value from 0.5 (no discrimination) to 1.0 (perfect discrimination), as well as intermediate values of 0.7 (good discrimination) and 0.8 (excellent discrimination).[78]

Explained variation (R^2): McFadden's Pseudo R^2 is an overall performance measure of model fit and describes the amount of variation explained in the model. Values between 0.2 to 0.4 are indicative of excellent model fit.[79]

Brier score: is another measure of overall performance that addresses calibration and the sharpness of the predictive distribution of the outcome variable. It can range from 0 to 1, and in general lower scores are indicative of better model fit.[80]

3.3.6 Internal validation

Since the above measures of calibration, discrimination and overall model performance for the model are calculated from the same data in which the model was originally developed, this apparent performance of the model can lead to optimistic and overfitted models. To correct for optimism and overfitting, the model can be internally validated using data re-sampling techniques to assess its performance in relation to the apparent performance calculated prior. A popular and effective data re-sampling technique for internal validation is bootstrap validation. Bootstrapping is a technique that can be used to create new datasets of the same size as the original dataset, by the process of random sampling with replacement from the original dataset.[81] Additionally, bootstrapping can derive a sampling distribution nonparametrically and as such does not require assumptions about the form of the population from which the original dataset is a sample of.[82] Bootstrap validation in this study includes:[67]

1) Developing the prediction model using the original dataset and determining the model's apparent performance.
2) Generation of a bootstrap sample by random sampling with replacement, to create a dataset of the same size as the original.
3) Developing a model using the bootstrap sample and performing variable selection with backward elimination automated variable selection.

4) Determine the apparent performance of the bootstrap model on the bootstrap sample (bootstrap performance).
5) Determine the performance of the bootstrap model in the original dataset (test performance).
6) Calculate the difference between the bootstrap performance and test performance; this is indicative of the optimism between the bootstrap model and the original dataset.
7) Repeat steps 2 to 6, 100 times.
8) Average the estimates of optimism produced by the 100 different models, and then subtract these values from the apparent performance produced in the original model, to obtain optimism-corrected estimates of performance.

The measures of performance calculated for each of the 100 bootstrap models were again: calibration plots, c-indexes, McFadden's Pseudo R^2 and Brier scores. Optimism-corrected performance estimates were calculated for only c-indexes, McFadden's Pseudo R^2 and Brier scores as these provided quantitative estimates. Additionally, the number of times a covariate was selected in each of the 100 bootstrap models was recorded, to get a better understanding of some of the covariates that are more frequently included in each of the models and hence might be essential predictors of the outcome variable.

3.3.7 Bootstrapping confidence intervals for covariate coefficients

To better increase the precision of our odds ratios produced from our final model, 95% confidence intervals were calculated using bootstrapping with 1000 bootstraps for each covariate. Having over 1000 bootstrap repetitions, allows for the construction of bias-corrected, accelerated 95% confidence intervals which are more accurate than the traditional confidence intervals.[82]

3.3.8 An example of using the prediction model

Finally, a worked example using a random individual assigned to CSRT and another random individual assigned to CORP from the original dataset will be applied to the prediction model to determine the predicted probability of these individuals to be referred to CORP (coded as 1 in our dataset), using the below formula:

$$P_{CORP} = e^{(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \ldots \beta_j X_j)} / (1 + e^{(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \ldots \beta_j X_j)})$$

Additionally, the percent likelihood of receiving CORP can be calculated as:

Percent likelihood = P_{CORP} x 100

Chapter 4: Results

4.1 Descriptive statistics

A complete case analysis resulted in a dataset of 671 patients with fully complete data (Figure 11).

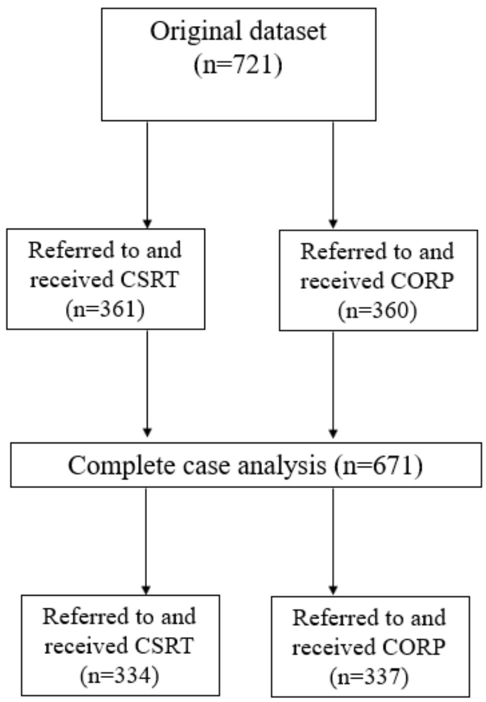


Figure 11. Participant flow diagram after complete case analysis.

Descriptive statistics are provided in Table 8. Within the study cohort, 337 individuals were referred to CORP, while 334 individuals were referred to CSRT, approximately a 50% split between the referral frequency to the two outpatient programs. The mean age of the study cohort was 66.87 (SD: 13.62) years, and 54.5% were males. The mean number of comorbidities patients had at admission to inpatient rehabilitation was 5.28 (SD: 1.71). In terms of vocational status, most patients were retired (73.2%) or employed (20.4%). Prior to outpatient rehabilitation admission, most patients lived at home (88.4%), with a minority living in long term care (8.9%) and acute care (2.7%).

The majority of patients had a caregiver (80.3%) and were from urban areas within the Southwest LHIN (94.8%). The mean distance patients had to travel to get to Parkwood Institute was 17.52 (SD: 18.48) km. Most patients had either a unilateral right hemisphere stroke (36.5%) or a left hemisphere stroke (49.5%). In terms of stroke severity, the cohort was composed of 20.7% mild, 48% moderate, and 31.3% severe strokes. The mean inpatient FIM total discharge score was 103.85 (SD: 19.02), with a mean motor sub-score of 75.01 (SD: 16.13), and a mean cognitive sub-score of 28.84 (SD: 5.38). The mean total FIM gain after inpatient rehabilitation was 24.34 (SD: 15.56), with a motor sub-score gain of 21.35 (SD: 14.34), and cognitive sub-score gain of 2.93 (SD: 3.47). For the CIHI data elements most patients reported no pain (71.7%); were independent in verbal (54.7%), written (24.6%), and auditory communication (53.8%); independent in reading comprehension (36.7%); required assistance with financial management (41.4%); oriented to time place, and self (90.2%); and were in good health (61.7%) at discharge from inpatient rehabilitation. The mean inpatient length of stay was 32.84 (SD: 19.45) days.

Table 8. Descriptive statistics of the study cohort split by CSRT and CORP, and univariable associations with the outcome variable (Outpatient program).

Study cohort (n=671)			**Univariable association with outcome variable (Outpatient Program)**		
Variable	**Mean ± SD** or **n (%)**		**Odds Ratio**	**95% CI**	**p-value**
Outpatient Program	**CSRT: 337 (50.2%)**	**CORP: 334 (49.8%)**			
Age (years)	69.99 ± 13.25	63.75 ± 13.30	0.967	0.956 to 0.979	p<0.001
Gender	Male: 172 (51.0%)	Male: 194 (58.1%)	1		
	Female: 165 (49.0%)	Female: 140 (41.9%)	0.740	0.551 to 0.994	p=0.046
Number of comorbidities	5.56 ± 1.67	5.00 ± 1.71	0.819	0.747 to 0.897	p<0.001
Vocational status	Employed: 47 (13.9%)	Employed: 90 (26.9%)	1		
	Unemployed: 12 (3.6%)	Unemployed: 24 (7.2%)	0.933	0.437 to 1.933	p=0.857
	Student: 1 (0.3%)	Student: 6 (1.8%)	3.032	0.355 to 25.903	p=0.311
	Retired: 277 (82.2%)	Retired: 214 (64.1%)	0.399	0.271 to 0.588	p<0.001
Living setting	Home: 287 (85.2%)	Home: 306 (91.6%)	1		
	Long term care: 35 (10.4%)	Long term care: 25 (7.5%)	0.701	0.419 to 1.174	p=0.177
	Acute care: 15 (4.5%)	Acute care: 3 (0.9%)	0.221	0.082 to 0.592	p=0.003
Presence of a caregiver	No: 87 (25.8%)	No: 45 (13.5%)	1		
	Yes: 250 (74.2%)	Yes: 289 (86.5%)	2.097	1.432 to 3.072	p<0.001
Rural or Urban	Urban: 317 (94.1%)	Urban: 319 (95.5%)	1		
	Rural: 20 (5.9%)	Rural: 15 (4.5%)	0.678	0.346 to 1.329	p=0.258
Distance to Parkwood Institute (km)	20.72 ± 20.38	14.26 ± 15.73	0.978	0.969 to 0.987	p<0.001
RCG	Right hemisphere: 116 (34.4%)	Right hemisphere: 129 (38.6%)	1		
	Left hemisphere: 170 (50.4%)	Left hemisphere: 162 (48.5%)	0.834	0.607 to 1.146	p=0.262
	Bilateral: 13 (3.9%)	Bilateral: 14 (4.2%)	1.077	0.511 to 2.274	p=0.845
	No paresis: 15 (4.5%)	No paresis: 13 (3.9%)	0.776	0.364 to 1.654	p=0.512
	Other stroke type: 23 (6.8%)	Other stroke type: 16 (4.8%)	0.617	0.312 to 1.220	p=0.165
RPG	Mild: 46 (13.6%)	Mild: 93 (27.8%)	1		
	Moderate: 168 (49.9%)	Moderate: 154 (46.1%)	0.413	0.275 to 0.620	p<0.001
	Severe: 123 (36.5%)	Severe: 87 (26.0%)	0.323	0.209 to 0.500	p<0.001

Inpatient FIM total discharge score	99.92 ± 19.47	107.75 ± 17.72	1.021	1.013 to 1.030	p<0.001
Inpatient FIM motor discharge sub-score	71.91 ± 16.68	78.10 ± 14.96	1.024	1.014 to 1.034	p<0.001
Inpatient FIM cognitive discharge sub-score	28.01 ± 5.38	29.66 ± 5.27	1.054	1.024 to 1.084	p<0.001
Inpatient FIM total gain	24.87 ± 15.18	23.84 ± 15.95	0.994	0.985 to 1.003	p=0.294
Inpatient FIM motor gain	21.92 ± 13.81	20.93 ± 14.61	0.993	0.982 to 1.003	p=0.251
Inpatient FIM cognitive gain	2.95 ± 3.63	2.91 ± 3.30	0.999	0.959 to 1.041	p=0.967
CIHI data elements presence of pain discharge score	No: 239 (70.9%)	No: 242 (72.5%)	1		
	Yes: 98 (29.1%)	Yes: 91 (27.2%)	0.901	0.652 to 1.247	0.531
	Unable to answer: 0 (0%)	Unable to answer: 1 (0.3%)	1		
CIHI data elements verbal communication discharge score	Independent: 161 (47.8%)	Independent : 206 (61.7%)	1		
	Supervision: 104 (30.9%)	Supervision: 70 (21.0%)	0.554	0.388 to 0.790	p=0.001
	Assistance: 50 (14.8%)	Assistance: 28 (8.4%)	0.516	0.321 to 0.830	p=0.006
	Dependent: 18 (5.3%)	Dependent: 22 (6.6%)	1.016	0.539 to 1.917	p=0.960
	Non-functional: 4 (1.2%)	Non-functional: 6 (1.8%)	1.127	0.351 to 3.611	p=0.841
	Not able to test: 0 (0.0%)	Not able to test: 2 (0.6%)	1		
CIHI data elements written communication discharge score	Independent: 58 (17.2%)	Independent : 107 (32.0%)	1		
	Supervision: 82 (24.3%)	Supervision: 66 (19.8%)	0.469	0.302 to 0.728	p=0.001
	Assistance: 64 (19.0%)	Assistance: 49 (14.7%)	0.424	0.262 to 0.684	p<0.001
	Dependent: 53 (15.7%)	Dependent: 34 (10.2%)	0.431	0.259 to 0.718	p=0.001
	Non-functional: 30 (8.9%)	Non-functional: 26 (7.8%)	0.497	0.274 to 0.899	p=0.021
	Not able to test: 50 (14.8%)	Not able to test: 52 (15.6%)	0.568	0.351 to 0.917	p=0.021
CIHI data elements auditory communication discharge score	Independent: 165 (49.0%)	Independent : 196 (58.7%)	1		
	Supervision: 121 (35.9%)	Supervision: 91 (27.2%)	0.680	0.490 to 0.945	p=0.022
	Assistance: 46 (13.6%)	Assistance: 30 (9.0%)	0.649	0.403 to 1.047	p=0.076
	Dependent: 4 (1.2%)	Dependent: 13 (3.9%)	2.251	0.787 to 6.439	p=0.013
	Non-functional: 1 (0.3%)	Non-functional: 3 (0.9%)	2.597	0.268 to 25.194	p=0.410

	Not able to test: 0 (0%)	Not able to test: 1 (0.3%)	1		
CIHI data elements reading comprehension discharge score	Independent: 92 (27.3%)	Independent: 154 (46.1%)	1		
	Supervision: 113 (30.3%)	Supervision: 90 (26.9%)	0.512	0.355 to 0.738	p<0.001
	Assistance: 73 (21.7%)	Assistance: 33 (9.9%)	0.305	0.191 to 0.486	p<0.001
	Dependent: 28 (8.3%)	Dependent: 28 (8.4%)	0.627	0.356 to 1.102	p=0.105
	Non-functional: 8 (2.4%)	Non-functional: 8 (2.4%)	0.862	0.335 to 2.216	p=0.757
	Not able to test: 23 (6.8%)	Not able to test: 21 (6.3%)	0.578	0.315 to 1.063	p=0.078
CIHI data elements financial management discharge score	Independent: 48 (14.2%)	Independent: 88 (26.3%)	1		
	Supervision: 36 (10.7%)	Supervision: 34 (10.2%)	0.557	0.314 to 0.989	p=0.046
	Assistance: 145 (43.0%)	Assistance: 133 (39.8%)	0.516	0.340 to 0.784	p=0.002
	Dependent: 108 (32.0%)	Dependent: 79 (23.7%)	0.424	0.273 to 0.660	p<0.001
CIHI data elements orientation discharge score	Oriented to time, place and self: 296 (87.8%)	Oriented to time, place and self: 309 (92.5%)	1		
	Oriented to one or two items: 40 (11.9%)	Oriented to one or two items: 23 (6.9%)	0.589	0.353 to 0.984	p=0.043
	Oriented to none of the items: 1 (0.3%)	Oriented to none of the items: 2 (0.6%)	1.903	0.172 to 21.094	p=0.600
CIHI data elements general health status discharge score	Poor: 2 (0.6%)	Poor: 4 (1.2%)	1		
	Fair: 40 (11.9%)	Fair: 29 (8.7%)	0.375	0.644 to 2.184	p=0.275
	Good: 206 (61.1%)	Good: 208 (62.3%)	0.516	0.094 to 2.847	p=0.448
	Very good: 71 (21.1%)	Very good: 67 (20.1%)	0.480	0.085 to 2.702	p=0.405
	Excellent: 18 (5.3%)	Excellent: 26 (7.8%)	0.714	0.120 to 4.264	p=0.712
Inpatient length of stay	34.97 ± 17.12	30.63 ± 21.52	0.988	0.980 to 0.996	p=0.002

Note: CI=confidence interval; CIHI=Canadian Institute of Health Information; CORP= Comprehensive Outpatient Rehabilitation Program; CSRT=Community Stroke Rehabilitation Team; FIM= functional independence measure; km=kilometers; RCG= rehabilitation client group; RPG=rehabilitation patient group; SD=standard deviation.

Odds ratio interpretation: Represents the odds of a covariate to influence referral to CSRT (more likely, if odds ratio less than 1) or to CORP (more likely, odds ratio greater than 1) without adjusting for other covariates. Statistical significance was taken at α=0.05.

4.2 Linearity assumption for continuous variables in a logistic regression model

The linearity assumption was checked for the following continuous variables: age, number of comorbidities, distance to Parkwood Institute, discharge inpatient FIM total score, motor and cognitive scores, inpatient FIM total, motor and cognitive gains, and inpatient length of stay. Visually inspecting the component residual plots, most variables met the linearity assumption. However, for the variable distance to Parkwood Institute, for more extreme values the lowess smooth line deviated from the line of best fit (Figure 12c), but these values were at least two standard deviations higher than the mean distance to Parkwood Institute score. For both, inpatient FIM cognitive discharge scores (Figure 12g) and inpatient FIM total gain scores (Figure 12h), linearity slightly deviated for lower score values. For inpatient FIM motor gain, linearity deviated at both high and low extreme values (Figure 12i).

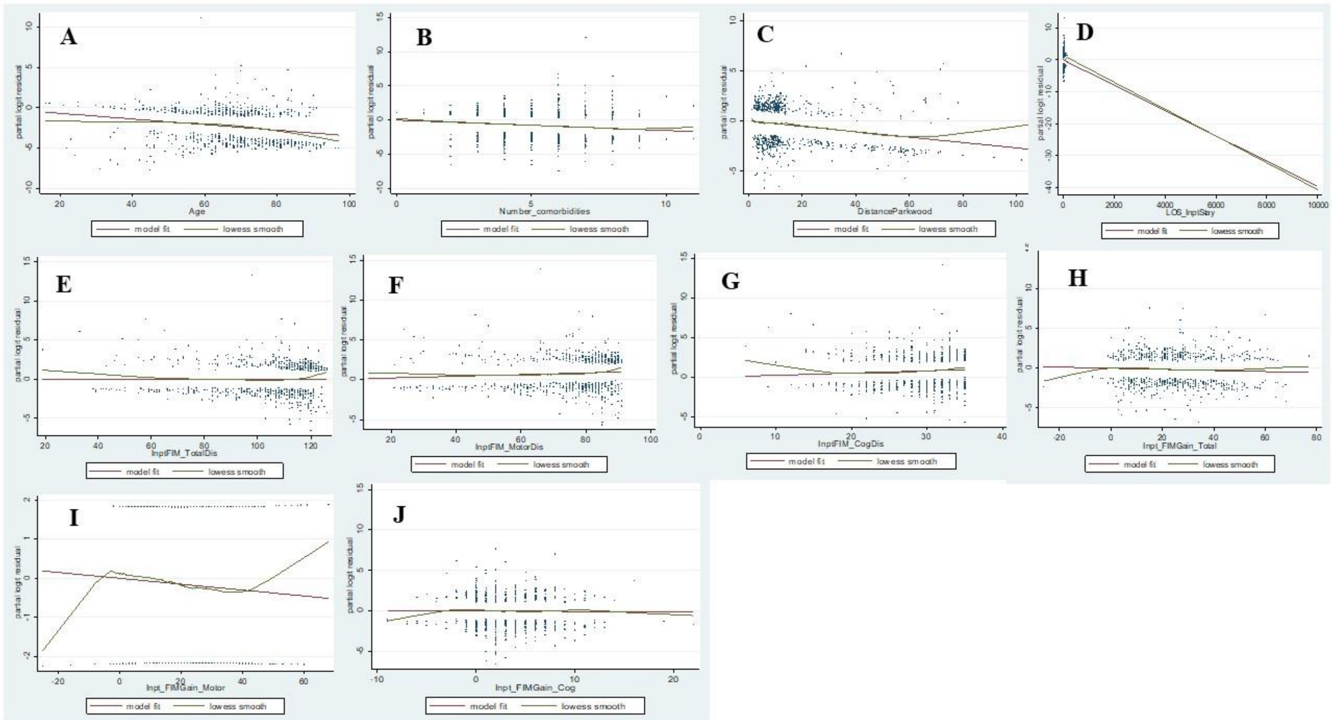


Figure 12. Component residual plots to check the linearity assumption for continuous variables: A) Age, B) Number of comorbidities, C) Distance to Parkwood Institute, D) Length of inpatient stay, E) Inpatient FIM total discharge score, F) Inpatient FIM motor discharge score, G) Inpatient FIM cognitive discharge score, H) Inpatient FIM total gain, I) Inpatient FIM motor gain, J) Inpatient FIM cognitive gain.

4.3 Univariable associations and collinearity predictor selection

Table 8 reports the univariable associations for each potential covariate and the outcome variable. The following variables were found to have p-values greater than the selection criterion value of α=0.25: rural or urban status (p=0.258), RCG type (left hemisphere stroke (p=0.262), bilateral stroke (p=0.845), no paresis (p=0.512)), inpatient FIM total gain (p=0.294), inpatient FIM motor gain (p=0.251), inpatient FIM cognitive gain (p=0.967), and the CIHI data elements general health status discharge score (fair (p=0.275), good (p=0.448), very good (p=0.405), excellent (p=0.712)). These variables were thus excluded from consideration as potential covariates in the multivariable model, as none of these were deemed worth keeping in terms of clinical and practical relevance, as their information could be captured by other variables (e.g. both, rural or urban status and distance to Parkwood Institute, relate to transportation barriers). A correlation matrix revealed that the following variables had a strong, significant correlation with the variable inpatient total FIM discharge score: inpatient FIM motor discharge sub-score ($r=0.967$, $p<0.001$), and inpatient FIM cognitive discharge sub-score ($r=0.635$, $p<0.001$). These two variables were excluded as well for consideration as potential covariates in the model because of their collinearity with inpatient total FIM discharge score.

4.4 Backward elimination variable selection

The remaining covariates were included as predictors in a multivariable logistic regression model for the odds of referral to CSRT or CORP (CSRT coded as 0, CORP coded as 1). The regression formula is:

$$\text{logit}\ \pi(x_1, x_2, \ldots, x_p) = \beta_0 + \beta_{Age} + \beta_{Gender} + \beta_{Number\_of\_comorbidities} + \beta_{Vocational\_status} + \beta_{Living\_setting} + \beta_{Presence\_of\_caregiver} + \beta_{Distance\_parkwood} + \beta_{RPG} + \beta_{DischargeFIM\_Total} + \beta_{CIHI\ data\ elements\_verbal\_communication} + \beta_{CIHI\ data\ elements\_written\_communication} + \beta_{CIHI\ data\ elements\_auditory\_communication} + \beta_{CIHI\ data\ elements\_reading\_comprehension} + \beta_{CIHI\ data\ elements\_financial\_management} + \beta_{CIHI\ data\ elements\_orientation} + \beta_{Inpatient\_LengthOfStay}$$

Table 9 describes the odds ratios and p-values of this initial model.

Table 9. Odds ratios, 95% confidence intervals, and p-values for initial multivariable logistic regression model for referral to CSRT or CORP.

Variable	**Odds ratio**	**95% CI**	**P-value**
Intercept	5.781	0.302 to 110.504	0.244
Age (years)	0.975	0.957 to 0.993	0.008
Gender Female	 0.738	 0.513 to 1.063	 0.102
Number of comorbidities	0.865	0.775 to 0.966	0.010
Vocational status Unemployed Student Retired	 0.811 0.511 0.671	 0.333 to 1.975 0.048 to 5.490 0.387 to 1.165	 0.645 0.580 0.156
Living setting Long term care Acute care	 1.581 0.749	 0.786 to 3.183 0.171 to 3.274	 0.458 0.601
Presence of a caregiver (yes)	3.041	1.859 to 4.978	<0.001
Distance to Parkwood Institute (km)	0.973	0.962 to 0.983	<0.001

RPG			
Mild	1		
Moderate	0.683	0.401 to 1.164	0.161
Severe	0.785	0.368 to 1.678	0.533
Inpatient total FIM discharge score	1.012	0.994 to 1.031	0.179
CIHI data elements verbal communication			
Independent	1		
Supervision	0.784	0.463 to 1.330	0.367
Assistance	0.563	0.232 to 1.367	0.204
Dependent	0.846	0.262 to 2.734	0.780
Non-functional	1.341	0.189 to 9.515	0.769
Not able to test	1275984	0 to Infinity	0.987
CIHI data elements written communication	1		
Independent	0.680	0.390 to 1.184	0.173
Supervision	1.064	0.543 to 2.084	0.857
Assistance	1.197	0.511 to 2.805	0.679
Dependent	1.033	0.408 to 2.616	0.945
Non-functional	0.947	0.483 to 1.861	0.876
Not able to test			
CIHI data elements auditory communication			
Independent	1		
Supervision	1.605	0.924 to 2.789	0.093
Assistance	2.072	0.816 to 5.264	0.126
Dependent	9.548	1.596 to 57.116	0.013
Non-functional	7.990	0.543 to 117.535	0.130
Not able to test	0.267	0 to Infinity	0.992
CIHI data elements reading comprehension	1		
Independent	0.466	0.272 to 0.797	0.005
Supervision	0.291	0.134 to 0.630	0.002
Assistance	0.715	0.269 to 1.898	0.500
Dependent	0.378	0.082 to 1.737	0.211
Non-functional	0.557	0.231 to 1.342	0.192
Not able to test			
CIHI data elements financial management			
Independent	1		
Supervision	0.671	0.335 to 1.342	0.259
Assistance	0.716	0.418 to 1.227	0.224
Dependent	0.755	0.369 to 1.613	0.425
CIHI data elements orientation Oriented to time, place, and self	1		

Oriented to one or two items Oriented to none of the items	0.771 0.610	0.369 to 1.161 0.031 to 11.972	0.490 0.745
Inpatient length of stay	0.993	0.980 to 1.007	0.325

AIC: 840.26

Note: AIC=Akaike information criterion; CI=confidence interval; CIHI=Canadian Institute of Health Information; CORP= Comprehensive Outpatient Rehabilitation Program; CSRT=Community Stroke Rehabilitation Team; FIM= functional independence measure; km=kilometers; RCG= rehabilitation client group; RPG=rehabilitation patient group.

Odds ratio interpretation: Represents the odds of a covariate to influence referral to CSRT (more likely, if odds ratio less than 1) or to CORP (more likely, odds ratio greater than 1) after adjusting for other covariates. Statistical significance was taken at α=0.05.

In this initial multivariable logistic regression model, the following covariates were found to be positively associated with receiving CSRT: age (OR: 0.975 [95% CI: 0.957 to 0.993], p<0.001), number of comorbidities (OR: 0.865 [95% CI: 0.775 to 0.966], p=0.010), distance travelled to Parkwood Institute (OR: 0.973 [95% CI: 0.962 to 0.983], p<0.001), certain categories of the CIHI data elements reading comprehension discharge score (requiring supervision compared to being independent [OR: 0.466 [95% CI: 0.272 to 0.797], p=0.005)] and, requiring assistance compared to being independent [OR: 0.291 [95% CI: 0.134 to 0.630], p=0.002]). The following covariates were found to be positively associated with receiving CORP: presence of a caregiver (OR: 3.041 [95% CI: 1.859 to 4.978], p<0.001), and one category of the CIHI data elements auditory communication discharge score (dependent compared to being independent, OR: 2.072 [95% CI: 0.816 to 5.264], p=0.013).

Backward elimination resulted in the following reduced model:

$$\text{logit}\ \pi\ (x_1, x_2, \ldots, x_p) = \beta_0 + \beta_{\text{Number\_of\_comorbidities}} + \beta_{\text{Presence\_of\_caregiver}} + \beta_{\text{Distance\_parkwood}} + \beta_{\text{Age}} + \beta_{\text{Gender}} + \beta_{\text{RPG}} + \beta_{\text{DischargeFIM\_Total}} + \beta_{\text{CIHI data elements\_auditory\_communication}} + \beta_{\text{CIHI data elements\_reading\_comprehension}}$$

Table 10 describes the odds ratios and p-values of this new model.

Table 10. Odds ratios, 95% confidence intervals, and p-values for multivariable logistic regression model for referral to CSRT or CORP produced after backward elimination.

Variable	Odds ratio	95% CI	P-value
Intercept	4.545	0.478 to 43.502	0.188
Age (years)	0.971	0.957 to 0.984	<0.001
Gender			
Female	0.742	0.521 to 1.055	0.10
Number of comorbidities	0.867	0.779 to 0.964	0.008
Presence of a caregiver (yes)	2.795	1.779 to 4.447	<0.001
Distance to Parkwood Institute (km)	0.971	0.961 to 0.981	<0.001
RPG			
Mild	1		
Moderate	0.573	0.351 to 0.927	0.024
Severe	0.608	0.321 to 1.144	0.124
Inpatient total FIM discharge score	1.017	1.004 to 1.032	0.014
CIDE auditory communication			
Independent	1		
Supervision	1.369	0.852 to 2.215	0.197
Assistance	1.581	0.759 to 3.301	0.221
Dependent	8.223	2.174 to 37.616	0.003
Non-functional	5.832	0.563 to 141.126	0.174
Not able to test	107359.1	4.825×10^{-43} to N.A.	0.983
CIDE reading comprehension			
Independent	1		
Supervision	0.437	0.266 to 0.710	0.001
Assistance	0.265	0.134 to 0.516	<0.001
Dependent	0.652	0.280 to 1.514	0.319
Non-functional	0.427	0.109 to 1.589	0.206
Not able to test	5.550	0.256 to 1.193	0.132

AIC: 812

Note: AIC=Akaike information criterion; CI=confidence interval; CIHI=Canadian Institute of Health Information; CORP= Comprehensive Outpatient Rehabilitation Program; CSRT=Community Stroke Rehabilitation Team; FIM= functional independence measure; km=kilometers; RCG= rehabilitation client group; RPG=rehabilitation patient group.

Odds ratio interpretation: Represents the odds of a covariate to influence referral to CSRT (more likely, if odds ratio less than 1) or to CORP (more likely, odds ratio greater than 1) after adjusting for other covariates. Statistical significance was taken at $\alpha=0.05$.

Backward elimination reduced the AIC from 840 to 812 compared to the initial multivariable logistic regression model. The following covariates were found to be positively associated with receiving CSRT: age (OR: 0.971 [95% CI: 0.957 to 0.984], p<0.001), number of comorbidities (OR: 0.867 [95% CI: 0.779 to 0.964], p=0.010), distance travelled to Parkwood Institute (OR: 0.971 [95% CI: 0.961 to 0.981], $p<0.001$), one category of RPG (moderate strokes compared to mild strokes (OR: 0.573 [95% CI: 0.351 to 0.927], $p=0.024$), and two categories of the CIHI data elements reading comprehension discharge score (requiring supervision compared to being independent (OR: 0.437 [95% CI: 0.266 to 0.710], $p=0.001$]) and, requiring assistance compared to being independent (OR: 0.265 [95% CI: 0.134 to 0.516], $p<0.001$]). The following covariates were found to be positively associated with receiving CORP: presence of a caregiver (OR: 2.795 [95% CI: 1.779 to 4.447], $p<0.001$), inpatient FIM total discharge scores (OR: 1.017 [95% CI: 1.004 to 1.032], $p=0.014$), and one category of the CIHI data elements auditory communication discharge score (dependent compared to being independent, OR: 8.223 [95% CI: 2.174 to 37.616], $p=0.003$).

4.5 Apparent performance measures

The apparent performance of the new model after backward elimination was evaluated on the development dataset.

Below is calibration plot of the predicted outcomes produced by the model compared to the outcomes actually observed in the dataset.

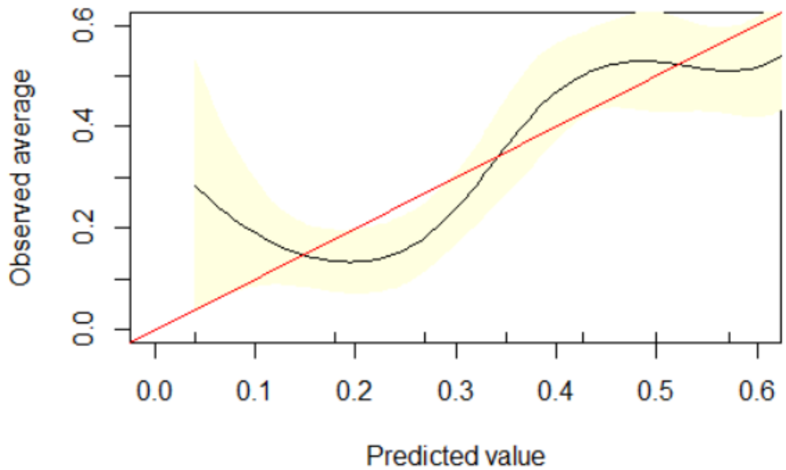


Figure 13. Calibration plot of predicted outcomes probabilities (x-axis) versus observed outcomes frequencies (y-axis) for a prognostic multivariable logistic regression model predicting referrals to CSRT or CORP.

Visually inspecting the calibration plot it has a sigmoidal shape that fits around the line with a slope of 1. So, there is evidence to believe that there is a moderate relationship between the degree of agreement between predicted and observed outcomes. This relationship was further strengthened with the resulting c-index of 0.77, which is indicative of a model having good discrimination between individuals who do and do not experience the outcome event [78]. The brier score value was 0.20, and McFadden's Pseudo R^2 was 0.17, just outside of the range of values for models with excellent fit.[79]

<u>4.6 Bootstrapping: interval validation and bias-corrected, accelerated 95% confidence intervals for model covariates</u>

Bootstrap models had calibration plots that ranged from closely resembling the plot produced in the apparent performance of the original model to plots where the degree of alignment was very close. Below is a random sample of nine plots produced from the 100 bootstrap models.

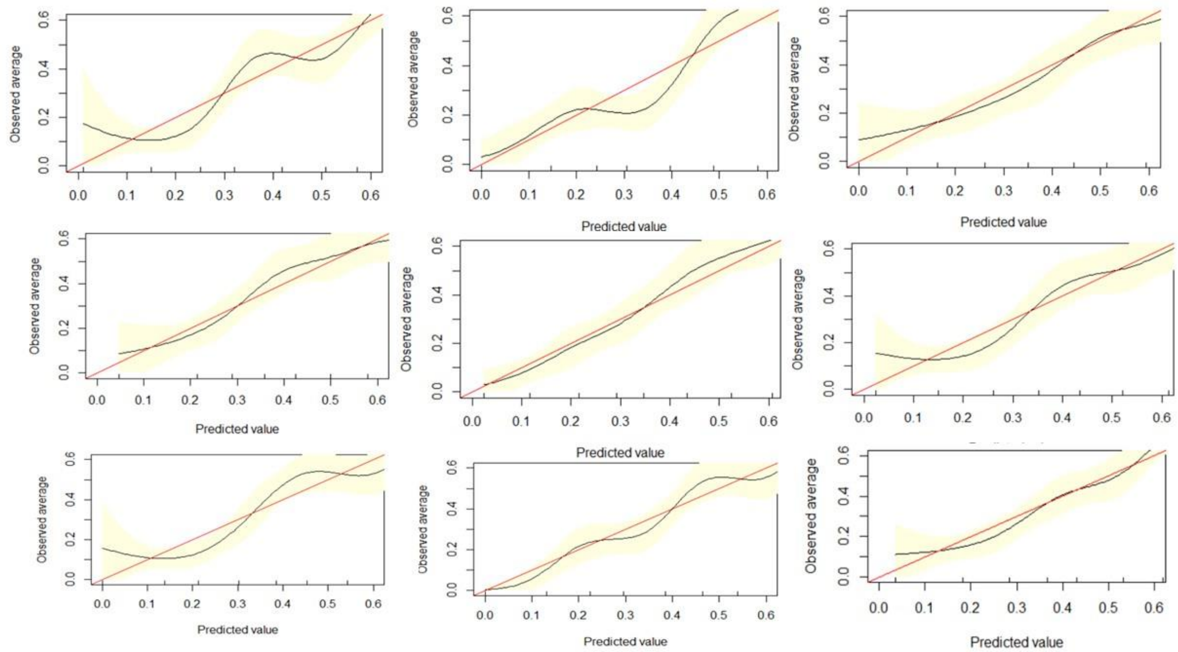


Figure 14. Random sample of nine calibration plots produced from the 100 bootstrap models.

The optimism-corrected performance estimates after bootstrapping were a c-index of 0.74 [95% CI: 0.738 to 0.745], a Brier score of 0.21 [95% CI: 0.220 to 0.224], and a McFadden's Pseudo R^2 of 0.12 [95% CI: 0.121 to 0.132]. Figure 14 describes the frequency with which a covariate was chosen in each of the 100 models produced during bootstrapping.

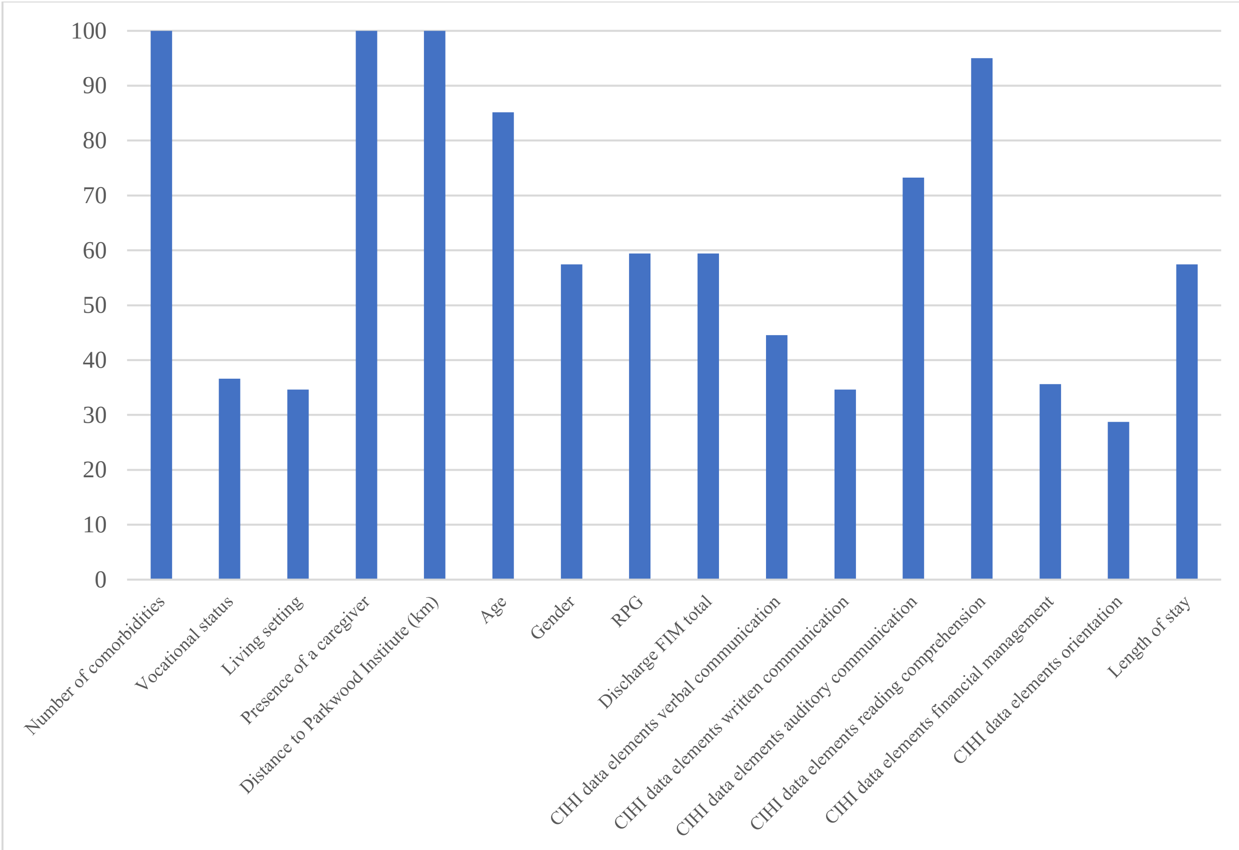


Figure 15. Frequency (%) with which a covariate was chosen during the model selection process in 100 different bootstrap samples.

Interestingly, variables most frequently chosen were those already included in the model produced from the original dataset. These included: number of comorbidities (100%), presence of a caregiver (100%), distance to Parkwood Institute (100%), CIHI data elements reading comprehension (95%), age (85%), CIHI data elements auditory communication (73%), RPG (59%), inpatient total FIM discharge score (59%), and gender (57%).

Table 11 describes the odds ratios and p-values of the final model with bias-corrected, accelerated confidence intervals calculated from bootstrapping.

Table 11. Odds ratios, bias-corrected, accelerated 95% confidence intervals, and p-values for multivariable logistic regression model for referral to CSRT or CORP produced after backward elimination.

Variable	Odds ratio	Bias-corrected, accelerated 95% CI	P-value
Intercept	4.545	0.381 to 53.622	0.188
Age (years)	0.971	0.781 to 0.974	<0.001
Gender Female	0.742	0.497 to 1.063	0.10
Number of comorbidities	0.867	0.780 to 0.974	0.008
Presence of a caregiver (yes)	2.795	1.696 to 4.398	<0.001
Distance to Parkwood Institute (km)	0.971	0.961 to 0.984	<0.001
RPG			
Mild	1		
Moderate	0.573	0.363 to 0.927	0.024
Severe	0.608	0.311 to 1.156	0.124
Inpatient total FIM discharge score	1.017	1.002 to 1.033	0.014
CIDE auditory communication			
Independent	1		
Supervision	1.369	0.832 to 2.292	0.197
Assistance	1.581	0.798 to 3.795	0.221
Dependent	8.223	1.670 to 69.403	0.003
Non-functional	5.832	2.61×10^{-7} to 9.383×10^{6}	0.174
Not able to test	107359.1	2.51×10^{4} to 2.915×10^{5}	0.983
CIDE reading comprehension			
Independent	1		
Supervision	0.437	0.269 to 0.729	0.001
Assistance	0.265	0.134 to 0.508	<0.001
Dependent	0.652	0.269 to 1.700	0.319
Non-functional	0.427	0.0956 to 2.528	0.206
Not able to test	5.550	0.237 to 1.251	0.132

AIC: 812

Note: AIC=Akaike information criterion; CI=confidence interval; CIHI=Canadian Institute of Health Information; CORP= Comprehensive Outpatient Rehabilitation Program; CSRT=Community Stroke Rehabilitation Team; FIM= functional independence measure; km=kilometers; RCG= rehabilitation client group; RPG=rehabilitation patient group.

Odds ratio interpretation: Represents the odds of a covariate to influence referral to CSRT (more likely, if odds ratio less than 1) or to CORP (more likely, odds ratio greater than 1) after adjusting for other covariates. Statistical significance was taken at α=0.05.

4.7 Applying the prediction model, worked examples

The following formula was used to calculate the probability of an individual to be referred to CORP:

$P_{CORP} = e^{(\beta_0 + \beta_{Number\_of\_comorbidities} + \beta_{Presence\_of\_caregiver} + \beta_{Distance\_parkwood} + \beta_{Age} + \beta_{Gender} + \beta_{RPG} + \beta_{DischargeFIM\_Total} + \beta_{CIHI\ data\ elements\_auditory\_communication} + \beta_{CIHI\ data\ elements\_reading\_comprehension})} / (1 + e^{(\beta_0 + \beta_{Number\_of\_comorbidities} + \beta_{Presence\_of\_caregiver} + \beta_{Distance\_parkwood} + \beta_{Age} + \beta_{Gender} + \beta_{RPG} + \beta_{DischargeFIM\_Total} + \beta_{CIHI\ data\ elements\_auditory\_communication} + \beta_{CIHI\ data\ elements\_reading\_comprehension})})$

Substituting the relevant beta-coefficients, the formula is:

P_{CORP} = e (1.514 -0.142(Number_of_comorbidities) + 1.028(Presence_of_caregiver) -0.029(Distance_parkwood) -0.030(Age) -0.298(Gender) +[-0.557(RPG_moderate) or -0.498(RPG_severe)] + 0.017(DischargeFIM_Total) + [0.314(CIHI data elements_auditory_communication_supervision) or 0.458(CIHI data elements_auditory_communication_assistance) or 2.107(CIHI data elements_auditory_communication_dependent) or 1.763(CIHI data elements_auditory_communication_NonFunctional) or 11.584 (CIHI data elements_auditory_communication_NotAbleToTest)] + [-0.829(CIHI data elements_reading_comprehension_supervision) or -1.329(CIHI data elements_reading_comprehension_assistance) or -0.428(CIHI data elements_reading_comprehension_dependent) or -0.852(CIHI data elements_reading_comprehension_NonFunctional) or -0.589(CIHI data elements_reading_comprehension_NotAbleToTest)] / [1 + e (1.514 -0.142(Number_of_comorbidities) + 1.028(Presence_of_caregiver) -0.029(Distance_parkwood) -0.030(Age) -0.298(Gender) +[-0.557(RPG_moderate) or -0.498(RPG_severe)] + 0.017(DischargeFIM_Total) + [0.314(CIHI data elements_auditory_communication_supervision) or 0.458(CIHI data elements_auditory_communication_assistance) or 2.107(CIHI data elements_auditory_communication_dependent) or 1.763(CIHI data elements_auditory_communication_NonFunctional) or 11.584 (CIHI data elements_auditory_communication_NotAbleToTest)] + [-0.829(CIHI data elements_reading_comprehension_supervision) or -1.329(CIHI data elements_reading_comprehension_assistance) or -0.428(CIHI data elements_reading_comprehension_dependent) or -0.852(CIHI data elements_reading_comprehension_NonFunctional) or -0.589(CIHI data elements_reading_comprehension_NotAbleToTest)]

The dataset was stratified by outpatient assignment (i.e. CSRT or CORP) to select a study participant from CSRT and CORP to apply the model in. A web software was used to randomly select a participant from each stratum to avoid selection bias.[83]

Here's the model applied to a random study participant that received CSRT:

$P_{CORP} = e^{(1.514 - 0.142(7) + 1.028(1) - 0.029(7.6) - 0.030(85) - 0.298(0) - 0.557(1) + 0.017(85) + 0.458(1) – 1.329(2)} / (1 + e^{(1.514 - 0.142(7) + 1.028(1) - 0.029(7.6) - 0.030(85) - 0.298(1) - 0.557(1) + 0.017(85) + 0.458(1) – 1.329(2)})$

$P_{CORP} = 0.0589/ (1 + 0.0589) = 0.0556$

The percent likelihood is 5.56% of this individual receiving CORP.

Here's the model applied to a random study participant that received CORP:

$P_{CSRT} = e^{(1.514 - 0.142(5) + 1.028(1) - 0.029(17.6) - 0.030(60) - 0.298(1) + 0.017(122)} / 1 + e^{(1.514 - 0.142(5) + 1.028(1) - 0.029(17.6) - 0.030(60) - 0.298(1) + 0.017(122)}$

6.643/ (1+6.643) = 0.869

The percent likelihood is 86.9%.

The model gives a much higher percent likelihood of receiving CORP to the individual that actually was referred to CORP (86.9%) than the one who went to CSRT (5.56%).

Chapter 5: Discussion

This thesis attempted to develop a prognostic multivariable model of the clinical decision-making process for stroke outpatient referrals at Parkwood Institute, a center that has both a home-based and hospital-based outpatient service and is an example of a stroke outpatient rehabilitation model recommended by the Canadian Stroke Best Practices. Characterising referral patterns to these two services allows for the identification and generalization of clinical and demographic characteristics that rehabilitation clinicians consider and prioritize during the triage process to stroke outpatient services in a Canadian setting. This is novel and has never been explored before. Additionally, understanding the differences in patient populations referred to each of these two services is pivotal before comparisons between the programs can be conducted.

5.1 Covariates included in the prediction model

The final prognostic model included nine covariates: 1) the number of comorbidities a patient had at admission to Parkwood Institute's inpatient stroke unit; 2) if the patient had a caregiver present; 3) the distance in kilometers the patient lived from Parkwood Institute; 4) their age; 5) gender; 6) their RPG assignment which is a proxy for stroke severity; 7) their inpatient discharge total FIM score; and 8,9) auditory communication and reading comprehension abilities assessed by the CIHI data elements questionnaire. Speculation as to why these variables were considered important in the referral process is discussed below.

5.1.1 Number of comorbidities

Patients in our study cohort presented with various comorbidities in addition to their stroke diagnosis on admission to the inpatient unit. Comorbidities as defined by ICD-10 categories included: certain infectious diseases and parasites (e.g. enterocolitis, herpes zoster, chronic viral hepatitis); neoplasms in miscellaneous areas of the body; immune and blood disorders (e.g. anaemia, thrombocytopenia, haemophilia); endocrine and metabolic diseases (e.g. hypothyroidism, diabetes mellitus, obesity, hyperlipidemia); mental and behavioural disorders (e.g. dementia, substance abuse disorders including alcohol, tobacco, and cannabinoids, depression, schizophrenia); diseases of the nervous system (e.g. Parkinson’s disease, epilepsy, migraines, transient cerebral ischaemic attacks, sleep apnoea, hemiplegia); disorders of the eye (e.g. cataracts, glaucoma, diplopia); diseases of the ear (e.g. vertigo, sensorineural hearing loss); diseases of the circulatory system (e.g. hypertension, aortic valve stenosis, atrial fibrillation); diseases of the respiratory system (e.g. chronic obstructive pulmonary disease, asthma); diseases of the digestive system (e.g. gastro-oesophageal reflux disease, constipation, irritable bowel syndrome); diseases of the musculoskeletal system and connective tissues (e.g. gout, arthritis, osteoporosis); diseases of the genitourinary system (e.g. chronic kidney disease, urinary tract infection); and other common stroke sequalae.

Only a small number of strokes (approximately 6%) occur in isolation without any comorbidities.[84] Unfortunately, rehabilitation often assumes a single disease focus paradigm when treating stroke patients, and comorbidities are treated as secondary sequelae rather than factors that can lead to harmful interactions between treatments and outcomes if not addressed correctly.[84] Comorbidities have been used as predictors in other stroke rehabilitation outcomes such as length of stay and overall level of disability.[85] Comorbidities such as congestive heart failure, chronic kidney disease, atrial fibrillation, and acute renal failure were associated with longer length of stay; while urinary tract infections were indicative of higher levels of disability.[85] Notably, there is evidence that stroke patients with higher Charlson Comorbidity Index (a measure of multimorbidity) scores had increased odds of death at one year post-stroke.[86]

Based on our model, patients with a higher number of comorbidities were significantly more likely to be referred to CSRT than CORP for stroke outpatient rehabilitation. As mentioned above, the range of comorbidities patients had in our study was large and diverse. Some of these conditions require intensive medical management (i.e. Parkinson's disease, advanced heart failure) and can even leave patients bedridden. As such, being a multimorbid individual, might have influenced why a patient was referred to home-based outpatient rehabilitation through CSRT, as these health conditions can make frequent travel to a hospital difficult and are better managed in a patient's home.

5.1.2 Presence of a caregiver

Caregivers play a pivotal role in the management of a stroke survivor after their discharge from inpatient rehabilitation. A caregiver can be informal in the form of a family member or friend, or formal as in the case of a paid healthcare professional. Caregivers provide physical and emotional assistance to a stroke survivor.[87] It is estimated that 68-74% of stroke survivors require the assistance of informal caregivers to perform their activities of daily living once they are discharged from rehabilitation.[88] As a result, a lot of duties and responsibilities once assumed by the rehabilitation team are shifted to the caregiver. Caregiver burden refers to the physical and emotional weight required by caregivers in caring for their loved ones after a stroke.[87] Caregiver burden can include feelings of incompetence, mental health decline, disrupted social relationships, economic instability, and stress management. Depression in caregivers is a major factor; and some caregivers exhibit higher depressive symptoms than the stroke survivors whom they care for.[89] A review of dyad interventions which target both the stroke survivor and their caregivers after discharge from rehabilitation found they are effective in alleviating caregiver anxiety and depression and improving satisfaction, but findings were mixed in relation to caregiver quality of life.[89] Caregivers' worries stem from a lack of understanding of post-stroke care including: medication administration, physical care, nutrition, safety with transfers, stroke recurrence, stroke risk factor management and recognizing the signs and symptoms of a stroke.[89,90] Importantly, the worries experienced by caregivers can be alleviated with the provision of educational resources and communication from the healthcare team to the caregiver.

In our study, it was found that having a caregiver was significantly associated with a referral to hospital-based outpatient rehabilitation through CORP. This finding may be attributed to the rehabilitation team relying on caregivers transporting patients to and from the hospital for rehabilitation visits. As previously mentioned, caregivers can often feel completely overwhelmed after a patient has been discharged from inpatient rehabilitation. Allowing for regular scheduled outpatient visits at the hospital allows an opportunity for the caregiver to connect with not only treating therapists but all members of the rehabilitation team about questions and concerns they had regarding post-stroke management. Finally, it creates a strong social support system for the caregiver and patient.

5.1.3 Distance travelled to Parkwood Institute in kilometers

Not surprisingly, the model found that patients who lived further away from Parkwood Institute were significantly more likely to be referred to CSRT. Transportation barriers have been documented as a complaint of American stroke patients in accessing outpatient services.[58] Looking at the literature from other disease populations, transportation distances contributed largely to attrition of women veterans from accessing routine veteran's health administration care.[90] Similarly, there is a negative relationship between outpatient healthcare utilization and travel distance to these centers in individuals with depression and alcoholism.[92,93]

The model is in accord with the goals of CSRT, to serve patients for whom access to an outpatient facility is hindered by transportation barriers.

5.1.4 Age

It is known that stroke incidence increases with age.[94] It is often a covariate considered in prognostic and diagnostic models evaluating stroke outcomes. Prior prediction models have shown age to be important in predicting mortality at three and 12 months,[95] risk of delirium in the acute phase of injury,[96] the 10-year cumulative incidence of ischemic and hemorrhagic stroke,[97] activities of daily living performance,[98] ambulation and upper limb function,[99] and both excellent and poor functional status at six months post-stroke.[100]

In our model, it was found that older patients were significantly more likely to be referred to CSRT. Older patients are more susceptible to decreases in mobility and diminished activities of daily living.[98,99] As such transportation to the hospital may be an issue. Age and multimorbidity also seem to have a synergistic relationship, as older individuals often have more comorbidities.[101] Older patients might be living on their own because their spouses are deceased, or their children have moved away, and as such may not have a caregiver to provide them transportation to the hospital. Age was also one of the covariates found to influence referral patterns in the American stroke system captured in our literature review in Chapter 2. Older age was associated with admissions to skilled nursing facilities and home health services,[62] while younger age was associated with admissions to hospital-based outpatient rehabilitation.[66]

5.1.5 Gender

Gender was not a significant predictor in our model, but the direction of the odds ratio was indicative that females are more likely to be referred to CSRT than CORP. Some gender differences have been documented between female and male stroke survivors. A study of stroke outpatients found that females often report worse scores on the Nottingham health profile compared to males on quality of life domains such as housekeeping, social activities, family life, leisure time, emotional reactions and physical mobility.[102] As well, an examination of an acute care hospital registry over a 23-year period found that females differ from males in cardiovascular risk factors for stroke and stroke diagnosis subtypes.[103] Our literature review of the American stroke system found being female was associated with admissions home health services, while males were admitted to hospital-based outpatient rehabilitation.[62,66] Females also tend to outlive their spouses, so it would be interesting to see if this variable has an interaction with the presence of a caregiver. Though, not a statistically significant predictor in our model, gender from past literature is associated with differences in patient outcomes, stroke onset characteristics, and referral trends.

5.1.6 RPG status

The model found that moderate compared to mild strokes were significantly more often referred to CSRT than CORP. Though not significant, the direction of the odds ratio comparing severe to mild strokes indicated that they too were more often referred to CSRT. Clinicians therefore tend to send patients with greater stroke severity to home-based outpatient care, while milder strokes are rehabilitated in hospital-based outpatient services. Stroke severity is considered an important variable throughout many phases of the rehabilitation continuum. In acute care, it influences discharge destination. During inpatient rehabilitation, RPGs determine patient length of stay benchmarks.[19] In the outpatient phase, moderate and severe strokes have more functional and cognitive deficits, which can make travel to the hospital difficult and their rehabilitation needs would be better met in their homes. This imbalance in stroke severity between the two outpatient programs is a factor that should be considered in future evaluation of the efficacy of the two programs as a potential confounder.

5.1.7 Inpatient FIM discharge score

The FIM is an outcome measure, widely known and used throughout the rehabilitation continuum for the evaluation of both cognitive and motor functional status in stroke survivors.[104] The FIM was designed to measure burden of care but is used as a measure of independence with higher scores indicative of greater independence.[104] A review of the FIM to predict discharge destinations from acute care to inpatient rehabilitation or home with no services found that patients with high FIM scores (≥80) are 12 times more likely to be discharged home (OR=12.08 [95% CI: 3.55 to 41.07]), while those with very low FIM scores (≤39) are 3.4 times more likely to be discharged to institutional inpatient care.[105] The FIM does therefore carry some weight in decision-making as a prognostic tool for level of independence at discharge and discharge destination.

In our model, higher FIM scores were positively associated with a referral to CORP. Higher FIMs imply the patient has greater independent function in activities of daily living, and this can make travel to the hospital for rehabilitation easier. Conversely, those with lower FIMs have difficulties in performing their activities of daily living, so rehabilitation in home through CSRT would allow for easier transference of skills learned in rehabilitation to their everyday living environments. Importantly the difference in FIM score distribution between the two outpatient programs is another key clinical characteristic that might confound future analyses evaluating the efficacy of the two outpatient services.

5.1.8 CIHI data elements questionnaires: auditory communication and reading comprehension abilities

Two elements of the CIHI data elements relating to communication and cognitive deficits were found to influence referrals. Individuals who were dependent compared to independent in their auditory communication were referred significantly more to CORP, while, those who required supervision or assistance in their reading comprehension were referred significantly more to CSRT. Auditory communication deficits can impact activities of daily living and interpersonal relationships, while, reading comprehension can be related to many different facets of executive function, memory, attention and object recognition. These referral trends show that patients with cognitive communication deficits are receiving outpatient rehabilitation.

In summary it appears based on the prognostic model, that patients who have a higher number of comorbidities, live further away from Parkwood Institute, are older, have moderate strokes, lower FIM scores and have reading comprehension difficulties are referred more often to CSRT. Conversely, patients with a caregiver, higher FIM scores, and auditory communication problems are more likely to be referred to CORP.

5.2 Model performance

The model was revealed to have moderate to good performance. The calibration plot showed that the model wavered around the line of best fit with a slope of 1. This measure of apparent performance also varied the most between bootstrap models, with some having near perfect calibration, and others having a shape similar to the original model calibration plot. The optimism-corrected c-index was 0.74 [95% CI: 0.738 to 0.745] indicative of good discrimination, while, the optimism-corrected McFadden Pseudo R^2 was 0.12 [95% CI: 0.121 to 0.132], indicating a moderate model. Additionally, the optimism-corrected Brier score was still relatively low, 0.21 [95% CI: 0.220 to 0.224]. The real strength of bootstrapping though, was to see the consistency in which the variables chosen initially by backward elimination in our model were picked most often throughout the different bootstrap models. Finally, when the model was applied as a probability of receiving CORP in two worked examples, the model gave a much higher percent likelihood to the individual referred to CORP than the one referred to CSRT (86.9% versus 5.56%).

5.3 Study limitations

A limitation of the study was the use of automated variable selection methods to derive the covariates to be included in our final model. Backward elimination in particular has been criticized as producing models where predictors are sensitive to random fluctuations in the data.[106] A study evaluating model development for predicting mortality after acute myocardial infarction was created from a dataset of 29 covariates. The authors found during their internal validation of 1,000 bootstrap samples, 940 unique models emerged with variations in the covariates chosen. The distribution of the covariates chosen in the 1,000 models, showed that some variables were chosen very highly, whereas intermediate variables were much more randomly distributed.[106] Other simulation studies have found that a large proportion of selected predictors are independent of the outcome or are noise variables unrelated to the outcome.[107,108] Automated variable selection models can treat regression modelling as "black box" epidemiology, instead of creating models informed by clinical knowledge.[106] Nonetheless, backward elimination is still a method reported by the TRIPOD statement as being favourable in developing models, provided they are properly internally or externally validated.[67] In the current study, only 100 bootstrap samples were used, and our covariate distribution of the most frequent variables selected during bootstrapping happened to match the variables chosen in our initial backward elimination. If this were repeated with 1,000 bootstrap samples, it is possible a different and more random covariate distribution might appear.

The study was also limited through the use of RPG status as a proxy variable for stroke severity, because a measure specifically designed to estimate stroke severity like the National Institute of Health Stroke Scale (NIHSS) was not administered by clinicians during rehabilitation.[109] The RPG is calculated using both the motor and cognitive components of the FIM in addition to a patient's age. As a result, stroke severity measured by the RPG is reflective of functional disability in activities of daily living, as opposed to a measure of motor-specific impairments captured by the NIHSS. Our inferences about the relationship between stroke severity and outpatient referral destination could change if an established stroke severity measure such as the NIHSS was used instead of RPG status.

The dataset is limited in that certain variables which could impact referral decisions were not captured. These could include demographic variables like time since stroke, stroke type, ethnicity and socioeconomic status. Ethnicity and socioeconomic status were found in the literature review in chapter 2 to influence referral patterns in the American stroke system; minorities and individuals of lower socioeconomic status were associated with receiving outpatient rehabilitation. Type of stroke, as ischemic strokes are much more common than hemorrhagic strokes.[5] Time since stroke was expected to be similar for most of our cohort, as we looked at the transfer from inpatient to outpatient rehabilitation, patients admitted to inpatient rehabilitation are typically a few weeks or months from their stroke onset. However, if the model was to be applied to patients referred to outpatient rehabilitation regardless if they came from an inpatient unit, acute care or the community, time since stroke may be an important variable that might influence where a clinician would send a patient. For instance, patients referred from the community might be reluctant to drive to a hospital setting and would prefer rehabilitation at home, a setting they are already comfortable in. The model is thus best suited to be used for referral decisions from inpatient rehabilitation discharge and not other settings.

Lastly, the model is limited in that it is not externally validated. Since Parkwood Institute is the only rehabilitation center employing both home-based and hospital-based outpatient rehabilitation in the Southwest LHIN, a comparator cohort was not available to perform external validation. As such the model can only explain the trends seen in Parkwood Institute's decision-making process.

5.4 Future research and clinical implications

The model is the first to explore in a Canadian setting, the factors that are associated with decision-making to outpatient rehabilitation programs after discharge from an inpatient stroke rehabilitation unit. Knowledge of the model can inform inpatient rehabilitation clinicians at Parkwood Institute about the characteristics that they intentionally or inadvertently group patients by when deciding if they should receive outpatient rehabilitation in their homes or at the hospital. The model also offers a framework in the Southwest LHIN regarding decision-making patterns for the only established dual outpatient stroke rehabilitation program. If other centres of the Southwest LHIN offer both home-based and hospital-based rehabilitation programs concurrently, the model can be used as an example of the different characteristics clinicians at Parkwood Institute consider during their referral decision-making process. The model is still only applicable to the unique data and programs specific to outpatient rehabilitation at Parkwood Institute.

Knowledge of the model shows variables that are differently associated with referral to either outpatient service. These variables can be adjusted for to prevent confounding when evaluating the difference in efficacy on patient outcomes between the two outpatient programs. However, program efficacy comparisons are limited, because the only outcome measure common to both programs is the FIM. Although understanding the difference between programs on the FIM is valuable in terms of understanding functional independence for activities of daily living, it is still only one aggregate outcome measure and not a full representation of the different benefits these programs offer the patient. Additionally, when inspecting the data for the FIM at admission and discharge from both CSRT and CORP, therapists' adherence to recording this information is not as well documented as it is for inpatient rehabilitation. Many patients from the current study cohort would be excluded due to data missingness, unless methods like multiple imputation were used. Future research should consider the collection of the same outcome measures from both CSRT and CORP to better track patient progress and doing so would allow for a more equal comparison of efficacy between the two programs. An initiative by the national institute of health is the standardization of outcome measures collected in various health settings, known as the international consortium of health outcomes measurement (ICHOM). ICHOM has recently released a proposed set of outcome measures to collect on stroke survivors. Notably, these standardized outcomes include stroke severity measures (i.e. NIHSS), measures of disability (i.e Modified Rankin Scale); and the Patient-Reported Outcome Measurement Information System Short-Form (PROMIS-10) which measures: cognitive, motor, psychiatric, pain, and social functioning, as well as general health status and health related quality of life.[110] An initiative from researchers and policy makers is currently being drafted for the implementation of the ICHOM standard set of outcomes for stroke in the Southwest LHIN at admission, discharge, and 90-day follow-up from acute care, inpatient rehabilitation and outpatient rehabilitation. If this is successfully implemented, after a few years of data collection, studies of program efficacy between CSRT and CORP can be conducted with common outcomes measuring a variety of different domains.

5.5 Conclusions

In conclusion, the current study produced a prognostic multivariable prediction model that attempted to distinguish differences in patient characteristics between CSRT and CORP patients referred from Parkwood Institute's stroke inpatient rehabilitation unit. Knowledge of this model can be valuable to clinicians and policy makers at Parkwood Institute to reflect on their own practices, and as well should be disseminated to other rehabilitation centers in the Southwest LHIN and throughout Ontario considering implementing a home-based and hospital-based outpatient program.

6.0 References

1) Sacco, R. L., Kasner, S. E., Broderick, J. P., Caplan, L. R., Culebras, A., Elkind, M. S., ... & Janis, L. S. (2013). An updated definition of stroke for the 21st century: a statement for healthcare professionals from the American Heart Association/American Stroke Association. Stroke, 44(7), 2064-2089.
2) Hebert, D., Lindsay, M. P., McIntyre, A., Kirton, A., Rumney, P. G., Bagg, S., ... & Glasser, E. (2016). Canadian stroke best practice recommendations: Stroke rehabilitation practice guidelines, update 2015. International Journal of Stroke, 11(4), 459-484.
3) Richards, C. L., Malouin, F., & Nadeau, S. (2015). Stroke rehabilitation: clinical picture, assessment, and therapeutic challenge. In Progress in brain research (Vol. 218, pp. 253-280). Elsevier.
4) Heart and Stroke Foundation. Statistics. 2017; http://www.strokebestpractices.ca/news/the-heart-stroke-2017-stroke-report/. Accessed June 30, 2018.
5) Langhorne, P., Bernhardt, J., & Kwakkel, G. (2011). Stroke rehabilitation. The Lancet, 377(9778), 1693-1702.
6) Teasell, R., Mehta, S., Pereira, S., McIntyre, A., Janzen, S., Allen, L., ... & Viana, R. (2012). Time to rethink long-term rehabilitation management of stroke patients. Topics in stroke rehabilitation, 19(6), 457-462.
7) Franceschini, M., Caso, V., Zampolini, M., Negrini, S., & Giustini, A. (2009). The role of the physiatrist in stroke rehabilitation: a European survey. American journal of physical medicine & rehabilitation, 88(7), 596-600.
8) Hall R, O'Callaghan C, Bayley M, Meyer S, Khan F, Liu Y et al. Ontario Stroke

Evaluation Report 2010: Technical Report. Institute for Clinical Evaluative Sciences

Toronto, Ontario; 2010.

9) Pathways of Care for People with Stroke in Ontario. Canadian Institute for Health Information. 2012; https://secure.cihi.ca/free_products/Pathways_of_care_aib_en.pdf. Accessed July 2, 2018.

10) Fisher, R. J., Gaynor, C., Kerr, M., Langhorne, P., Anderson, C., Bautz-Holter, E., ... & Rønning, O. M. (2011). A consensus on stroke: early supported discharge. Stroke, 42(5), 1392-1397.

11) Hakkennes, S. J., Brock, K., & Hill, K. D. (2011). Selection for inpatient rehabilitation after acute stroke: a systematic review of the literature. Archives of physical medicine and rehabilitation, 92(12), 2057-2070.

12) Teasell, R., Meyer, M. J., Foley, N., Salter, K., & Willems, D. (2009). Stroke rehabilitation in Canada: a work in progress. Topics in stroke rehabilitation, 16(1), 11-19.

13) Govender, P., & Kalra, L. (2007). Benefits of occupational therapy in stroke rehabilitation. Expert review of neurotherapeutics, 7(8), 1013-1019.

14) Dragga, A. (2015). The Role of Speech-Language Pathologists in Stroke Rehabilitation. Rhode Island medical journal (2013), 98(12), 20.

15) Winstein, C. J., Stein, J., Arena, R., Bates, B., Cherney, L. R., Cramer, S. C., ... & Lang, C. E. (2016). Guidelines for adult stroke rehabilitation and recovery: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke, 47(6), e98-e169.

16) Clarke, D. J. (2014). Nursing practice in stroke rehabilitation: systematic review and meta-ethnography. Journal of clinical nursing, 23(9-10), 1201-1226.

17) Bindawas, S. M., Vennu, V., & Moftah, E. (2017). Improved functions and reduced length of stay after inpatient rehabilitation programs in older adults with stroke: a systematic review and meta-analysis of randomized controlled trials. NeuroRehabilitation, 40(3), 369-390.

18) Meyer, M. J., Pereira, S., McClure, A., Teasell, R., Thind, A., Koval, J., ... & Speechley, M. (2015). A systematic review of studies reporting multivariable models to predict functional outcomes after post-stroke inpatient rehabilitation. Disability and rehabilitation, 37(15), 1316-1323.

19) Meyer, M., Britt, E., McHale, H. A., & Teasell, R. (2012). Length of stay benchmarks for inpatient rehabilitation after stroke. Disability and rehabilitation, 34(13), 1077-1081.

20) Meyer, M. J. (2015). The impact of resource availability on patterns of discharge to inpatient rehabilitation after stroke in Ontario, Canada.

21) Ontario’s LHINs; http://www.lhins.on.ca/. Accessed July 7, 2018.

22) Southwest LHIN; http://www.southwestlhin.on.ca/aboutus/facts.aspx. Accessed July 7, 2018.

23) Southwest Stroke Project; http://www.swostroke.ca/about-swsp/. Accessed July 8, 2018.

24) Willems D. Southwestern Ontario Stroke Rehabilitation Action Planning Day Report. Southwestern Ontario Stroke Strategy; 2006.

25) Hall R, Khan F, O'Callaghan C, et al. Ontario Stoke Evaluaiton Report 2014: On Target

for Stroke Prevention and Care. 2014; http://www.ices.on.ca/Publications/Atlases-andReports/2014/Ontario-Stroke-Evaluation-Report-2014. Accessed July 9, 2018.

26) Allen, L. J. (2015). A cost-effectiveness study of home-based stroke rehabilitation.

27) Allen, L., Richardson, M., McIntyre, A., Janzen, S., Meyer, M., Ure, D., ... & Teasell, R. (2014). Community stroke rehabilitation teams: providing home-based stroke rehabilitation in Ontario, Canada. Canadian Journal of Neurological Sciences, 41(6), 697-703.

28) Allen, L., McIntyre, A., Janzen, S., Richardson, M., Meyer, M., Ure, D., & Teasell, R. (2016). Community Stroke Rehabilitation: How Do Rural Residents Fare Compared With Their Urban Counterparts?. Canadian Journal of Neurological Sciences, 43(1), 98-104.

29) Allen, L., John-Baptiste, A., Meyer, M., Richardson, M., Speechley, M., Ure, D., ... & Teasell, R. (2018). Assessing the impact of a home-based stroke rehabilitation programme: a cost-effectiveness study. Disability and rehabilitation, 1-6.

30) Rice, D., Janzen, S., McIntyre, A., Vermeer, J., Britt, E., & Teasell, R. (2016). Comprehensive Outpatient Rehabilitation Program: Hospital-Based Stroke Outpatient Rehabilitation. Journal of Stroke and Cerebrovascular Diseases, 25(5), 1158-1164.

31) Rice, D. B., McIntyre, A., Mirkowski, M., Janzen, S., Viana, R., Britt, E., & Teasell, R. (2017). Patient-centered goal setting in a hospital-based outpatient stroke rehabilitation center. PM&R, 9(9), 856-865.

32) CSRT referral form; https://www.sjhc.london.on.ca/sites/default/files/stroke_csrtreferralform.pdf. Accessed July 10, 2018.

33) CORP referral form; https://www.sjhc.london.on.ca/sites/default/files/pdf/stroke_corpreferralform.pdf. Accessed July 10, 2018.

34) Meldrum, M. L. (2000). A brief history of the randomized controlled trial: From oranges and lemons to the gold standard. Hematology/oncology clinics of North America, 14(4), 745-760.

35) Murad, M.H., Jaeschke, R., Devereaux, P.J., Kameshwar, P., Carrasco-Labra, A., Agoritsas, T., et al. (2015). The Process of a Systematic Review and Meta-Analysis. In Users' Guides to the Medical Literature: A Manual for Evidence-Based Clinical Practice, 3rd Edition (pp. 459-469). Editors: Guyatt, G., Rennie, D., Meade, O.M., & Cook, D.J. JAMA evidence.

36) Britton, M., & Andersson, A. (2000). Home rehabilitation after stroke: reviewing the scientific evidence on effects and costs. International Journal of Technology Assessment in Health Care, 16(03), 842-848.

37) Hillier, S., & Inglis-Jassiem, G. (2010). Rehabilitation for community-dwelling people with stroke: home or centre based? A systematic review. International Journal of Stroke, 5(3), 178-186.

38) Aydin, T., Taspinar, O., Kepekci, M., Keskin, Y., Erten, B., Gunel, M., ... & Mutluer, A. S. (2016). Functional independence measure scores of patients with hemiplegia followed up at home and in university hospitals. Journal of physical therapy science, 28(2), 553-557.

39) Chen, J., Jin, W., Dong, W. S., Jin, Y., Qiao, F. L., Zhou, Y. F., & Ren, C. C. (2017). Effects of home-based telesupervising rehabilitation on physical function for stroke survivors with hemiplegia: a randomized controlled trial. American journal of physical medicine & rehabilitation, 96(3), 152-160.

40) Lord, S., McPherson, K. M., McNaughton, H. K., Rochester, L., & Weatherall, M. (2008). How feasible is the attainment of community ambulation after stroke? A pilot randomized controlled trial to evaluate community-based physiotherapy in subacute stroke. Clinical rehabilitation, 22(3), 215-225.

41) Redzuan, N. S., Engkasan, J. P., Mazlan, M., & Abdullah, S. J. F. (2012). Effectiveness of a video-based therapy program at home after acute stroke: a randomized controlled trial. Archives of physical medicine and rehabilitation, 93(12), 2177-2183.

42) Olaleye, O. A., Hamzat, T. K., & Owolabi, M. O. (2014). Stroke rehabilitation: should physiotherapy intervention be provided at a primary health care centre or the patients’ place of domicile?. Disability and rehabilitation, 36(1), 49-54.

43) Gladman, J. R., Lincoln, N. B., & Barer, D. H. (1993). A randomised controlled trial of domiciliary and hospital-based rehabilitation for stroke patients after discharge from hospital. Journal of Neurology, Neurosurgery & Psychiatry, 56(9), 960-966.

44) Rudd, A. G., Wolfe, C. D., Tilling, K., & Beech, R. (1997). Randomised controlled trial to evaluate early discharge scheme for patients with stroke. Bmj, 315(7115), 1039-1044.

45) Rodgers, H., Soutter, J., Kaiser, W., Pearson, P., Dobson, R., Skilbeck, C., & Bond, J. (1997). Early supported hospital discharge following acute stroke: pilot study results. Clinical rehabilitation, 11(4), 280-287.

46) Holmqvist, L. W., Von Koch, L., Kostulas, V., Holm, M., Widsell, G., Tegler, H., ... & de Pedro-Cuesta, J. (1998). A randomized controlled trial of rehabilitation at home after stroke in southwest Stockholm. Stroke, 29(3), 591-597.

47) Baskett, J. J., Broad, J. B., Reekie, G., Hocking, C., & Green, G. (1999). Shared responsibility for ongoing rehabilitation: a new approach to home-based therapy after stroke. Clinical Rehabilitation, 13(1_suppl), 23-33.

48) Andersen, H. E., Schultz-Larsen, K., Kreiner, S., Forchhammer, B. H., Eriksen, K., & Brown, A. (2000). Can readmission after stroke be prevented?: results of a randomized clinical study: a postdischarge follow-up service for stroke survivors. Stroke, 31(5), 1038-1045.

49) Björkdahl, A., Nilsson, A. S. L., Grimby, G., & Sunnerhagen, K. S. (2006). Does a short period of rehabilitation in the home setting facilitate functioning after stroke? A randomized controlled trial. Clinical rehabilitation, 20(12), 1038-1049.

50) Duncan, P., Richards, L., Wallace, D., Stoker-Yates, J., Pohl, P., Luchies, C., ... & Studenski, S. (1998). A randomized, controlled pilot study of a home-based exercise program for individuals with mild and moderate stroke. Stroke, 29(10), 2055-2060.

51) Gilbertson, L., Langhorne, P., Walker, A., Allen, A., & Murray, G. D. (2000). Domiciliary occupational therapy for patients with stroke discharged from hospital: randomised controlled trial. Bmj, 320(7235), 603-606.

52) Gilbertson, L., & Langhorne, P. (2000). Home-based occupational therapy: stroke patients' satisfaction with occupational performance and service provision. British Journal of Occupational Therapy, 63(10), 464-468.

53) Lincoln, N. B., Walker, M. F., Dixon, A., & Knights, P. (2004). Evaluation of a multiprofessional community stroke team: a randomized controlled trial. Clinical Rehabilitation, 18(1), 40-47.

54) Roderick, P., Low, J., Day, R., Peasgood, T., Mullee, M. A., Turnbull, J. C., ... & Raftery, J. (2001). Stroke rehabilitation after hospital discharge: a randomized trial comparing domiciliary and day-hospital care. Age and Ageing, 30(4), 303-310.

55) Walker, M. F., Gladman, J. R. F., Lincoln, N. B., Siemonsma, P., & Whiteley, T. (1999). Occupational therapy for stroke patients not admitted to hospital: a randomised controlled trial. The Lancet, 354(9175), 278-280.

56) Wolfe, C. D., Tilling, K., & Rudd, A. G. (2000). The effectiveness of community-based rehabilitation for stroke patients who remain at home: a pilot randomized trial. Clinical rehabilitation, 14(6), 563-569.

57) Young, J. B., & Forster, A. (1992). The Bradford community stroke trial: results at six months. Bmj, 304(6834), 1085-1089.

58) Ayala, C. (2018). Use of Outpatient Rehabilitation Among Adult Stroke Survivors—20 States and the District of Columbia, 2013, and Four States, 2015. MMWR. Morbidity and Mortality Weekly Report, 67.

59) Hempler, I., Woitha, K., Thielhorn, U., & Farin, E. (2018). Post-stroke care after medical rehabilitation in Germany: a systematic literature review of the current provision of stroke patients. BMC health services research, 18(1), 468.

60) Rattray, N. A., Sico, J. J., Cox, L. M., Russ, A. L., Matthias, M. S., & Frankel, R. M. (2017). Crossing the communication chasm: Challenges and opportunities in transitions of care from the hospital to the primary care clinic. The Joint Commission Journal on Quality and Patient Safety, 43(3), 127-137.

61) Sandel, M. E., Wang, H., Terdiman, J., Hoffman, J. M., Ciol, M. A., Sidney, S., ... & Chan, L. (2009). Disparities in stroke rehabilitation: results of a study in an integrated health system in northern California. PM&R, 1(1), 29-40.

62) Freburger, J. K., Holmes, G. M., Ku, L. J. E., Cutchin, M. P., Heatwole-Shank, K., & Edwards, L. J. (2011). Disparities in postacute rehabilitation care for stroke: an analysis of the state inpatient databases. Archives of physical medicine and rehabilitation, 92(8), 1220-1229.

63) Szumilas, M. (2010). Explaining odds ratios. Journal of the Canadian academy of child and adolescent psychiatry, 19(3), 227.

64) Risk Ratios and Rate Ratios (Relative Risk). http://sphweb.bumc.bu.edu/otlt/MPH-Modules/EP/EP713_Association/EP713_Association3.html. Accessed July 30, 2018.

65) Nguyen, V. Q., PrvuBettger, J., Guerrier, T., Hirsch, M. A., Thomas, J. G., Pugh, T. M., & Rhoads III, C. F. (2015). Factors associated with discharge to home versus discharge to institutional care after inpatient stroke rehabilitation. Archives of physical medicine and rehabilitation, 96(7), 1297-1303.

66) Chan, L., Wang, H., Terdiman, J., Hoffman, J., Ciol, M. A., Lattimore, B. F., ... & Sandel, M. E. (2009). Disparities in outpatient and home health service utilization

following stroke: results of a 9-year cohort study in Northern California. PM&R, 1(11), 997-1003.

67) Moons, K. G., Altman, D. G., Reitsma, J. B., Ioannidis, J. P., Macaskill, P., Steyerberg, E. W., ... & Collins, G. S. (2015). Transparent Reporting of a multivariable prediction model for Individual Prognosis or Diagnosis (TRIPOD): explanation and elaboration. Annals of internal medicine, 162(1), W1-W73.

68) International Statistical Classification of Diseases and Related Health Problems. http://apps.who.int/classifications/icd10/browse/2010/en. Accessed July 31, 2018.

69) Rurality Index of Ontario score calculator. https://apps.oma.org/RIO/index.html. Accessed July 31, 2018.

70) Meyer, M., Britt, E., McHale, H. A., & Teasell, R. (2012). Length of stay benchmarks for inpatient rehabilitation after stroke. Disability and rehabilitation, 34(13), 1077-1081.

71) Keith, R. A. (1987). The functional independence measure: a new tool for rehabilitation. Advances in clinical rehabilitation, 2, 6-18.

72) White, I. R., & Carlin, J. B. (2010). Bias and efficiency of multiple imputation compared with complete-case analysis for missing covariate values. Statistics in medicine, 29(28), 2920-2931.

73) Royston, P., Moons, K. G., Altman, D. G., & Vergouwe, Y. (2009). Prognosis and prognostic research: developing a prognostic model. Bmj, 338, b604.

74) Fowlkes, E. B. (1987). Some diagnostics for binary logistic regression via smoothing. Biometrika, 74(3), 503-515.

75) Zhang, Z. (2016). Model building strategy for logistic regression: purposeful selection. Annals of translational medicine, 4(6).

76) Cohen, J. (1988). Set correlation and contingency tables. Applied Psychological Measurement, 12(4), 425-434.

77) Mazerolle, M. J. (2004). Appendix 1: Making sense out of Akaike's Information Criterion (AIC): its use and interpretation in model selection and inference from ecological data. Mouvements et reproduction des amphibiens en tourbières perturbées, 174-190.

78) Tripepi, G., Jager, K. J., Dekker, F. W., & Zoccali, C. (2010). Statistical methods for the assessment of prognostic biomarkers (Part I): discrimination. Nephrology dialysis transplantation, 25(5), 1399-1401.

79) McFadden, D. (1977). Quantitative methods for analyzing travel behavior of individuals: some recent developments. Institute of Transportation Studies, University of California.

80) Rufibach, K. (2010). Use of Brier score to assess binary predictions. Journal of clinical epidemiology, 63(8), 938-939.

81) Wu, C. F. J. (1986). Jackknife, bootstrap and other resampling methods in regression analysis. the Annals of Statistics, 14(4), 1261-1295.

82) Fox, J., & Weisberg, S. (2017). Bootstrapping Regression Models in R. An appendix to An R Companion to Applied Regression, Second edition.

83) Research Randomizer for simple random sampling. https://www.randomizer.org/#randomize. Accessed July 31, 2018.

84) Nelson, M. L., McKellar, K. A., Yi, J., Kelloway, L., Munce, S., Cott, C., ... & Lyons, R. (2017). Stroke rehabilitation evidence and comorbidity: a systematic scoping review of randomized controlled trials. Topics in stroke rehabilitation, 24(5), 374-380.

85) Mohamed, W., Bhattacharya, P., Shankar, L., Chaturvedi, S., & Madhavan, R. (2015). Which comorbidities and complications predict ischemic stroke recovery and length of stay?. The neurologist, 20(2), 27-32.

86) Goldstein, L. B., Samsa, G. P., Matchar, D. B., & Horner, R. D. (2004). Charlson Index comorbidity adjustment for ischemic stroke outcome studies. Stroke, 35(8), 1941-1945.

87) Rigby, H., Gubitz, G., & Phillips, S. (2009). A systematic review of caregiver burden following stroke. Stroke, 4(4), 285-292.

88) Bakas T., Champion V., Perkins S.M., Farran C.J., & Williams L.S. (2006). Psychometric testing of the revised 15-item Bakas Caregiving Outcomes Scale. Nursing Research, 55(5), 346-355.

89) Bakas, T., Clark, P. C., Kelly-Hayes, M., King, R. B., Lutz, B. J., & Miller, E. L. (2014). Evidence for stroke family caregiver and dyad interventions: a statement for healthcare professionals from the American Heart Association and American Stroke Association. Stroke, 45(9), 2836-2852.

90) Camak, D. J. (2015). Addressing the burden of stroke caregivers: a literature review. Journal of clinical nursing, 24(17-18), 2376-2382.

91) Friedman, S. A., Frayne, S. M., Berg, E., Hamilton, A. B., Washington, D. L., Saechao, F., ... & Phibbs, C. S. (2015). Travel time and attrition from VHA care among women veterans: how far is too far?. Medical care, 53(4 0 1), S15.

92) Marcus, S. C., Fortney, J. C., Olfson, M., & Ryan, N. D. (1997). Travel distance to outpatient treatment for depression. Psychiatric Services, 48(8), 1005.

93) Fortney, J. C., Booth, B. M., Blow, F. C., Bunn, J. Y., & Loveland Cook, C. A. (1995). The effects of travel barriers and age on the utilization of alcoholism

treatment aftercare. The American Journal of Drug and Alcohol Abuse, 21(3), 391-406.

94) Kelly-Hayes, M. (2010). Influence of age and health behaviors on stroke risk: lessons from longitudinal studies. Journal of the American Geriatrics Society, 58, S325-S328.

95) Ayis, S. A., Coker, B., Rudd, A. G., Dennis, M. S., & Wolfe, C. D. (2012). Predicting independent survival after stroke: a European study for the development and validation of standardised stroke scales and prediction models of outcome. J Neurol Neurosurg Psychiatry, jnnp-2012.

96) Oldenbeuving, A. W., de Kort, P. L. M., van der Sluijs, J. V. E., Kappelle, L. J., & Roks, G. (2013). An early prediction of delirium in the acute phase after stroke. J Neurol Neurosurg Psychiatry, jnnp-2013.

97) Ferket, B. S., Van Kempen, B. J., Wieberdink, R. G., Steyerberg, E. W., Koudstaal, P. J., Hofman, A., ... & Kronmal, R. A. (2014). Separate prediction of intracerebral hemorrhage and ischemic stroke. Neurology, 82(20), 1804-1812.

98) Veerbeek, J. M., Kwakkel, G., van Wegen, E. E., Ket, J. C., & Heymans, M. W. (2011). Early prediction of outcome of activities of daily living after stroke: a systematic review. Stroke, 42(5), 1482-1488.

99) Kwah, L. K., Harvey, L. A., Diong, J., & Herbert, R. D. (2013). Models containing age and NIHSS predict recovery of ambulation and upper limb function six months after stroke: an observational study. Journal of physiotherapy, 59(3), 189-197.

100) Reid, J. M., Dai, D., Christian, C., Reidy, Y., Counsell, C., Gubitz, G. J., & Phillips, S. J. (2012). Developing predictive models of excellent and devastating outcome after stroke. Age and ageing, 41(4), 560-564.

101) Lenzi, J., Avaldi, V. M., Rucci, P., Pieri, G., & Fantini, M. P. (2016). Burden of multimorbidity in relation to age, gender and immigrant status: a cross-sectional study based on administrative data. BMJ open, 6(12), e012812.

102) Franzén-Dahlin, Å., & Laska, A. C. (2012). Gender differences in quality of life after stroke and TIA: a cross-sectional survey of out-patients. Journal of clinical nursing, 21(15-16), 2386-2391.

103) Arboix, A., Cartanyà, A., Lowak, M., García-Eroles, L., Parra, O., Oliveres, M., & Massons, J. (2014). Gender differences and woman-specific trends in acute stroke: results from a hospital-based registry (1986–2009). Clinical neurology and neurosurgery, 127, 19-24.

104) Chumney, D., Nollinger, K., Shesko, K., Skop, K., Spencer, M., & Newton, R. A. (2010). Ability of Functional Independence Measure to accurately predict functional outcome of stroke-specific population: systematic review. Journal of Rehabilitation Research & Development, 47(1).

105) Thorpe, E. R., Garrett, K. B., Smith, A. M., Reneker, J. C., & Phillips, R. S. (2018). Outcome Measure Scores Predict Discharge Destination in Patients With Acute and Subacute Stroke: A Systematic Review and Series of Meta-analyses. Journal of Neurologic Physical Therapy, 42(1), 2-11.

106) Austin, P. C., & Tu, J. V. (2004). Automated variable selection methods for logistic regression produced unstable models for predicting acute myocardial infarction mortality. Journal of clinical epidemiology, 57(11), 1138-1146.

107) Flack, V. F., & Chang, P. C. (1987). Frequency of selecting noise variables in subset regression analysis: a simulation study. The American Statistician, 41(1), 84-86.

108) Derksen, S., & Keselman, H. J. (1992). Backward, forward and stepwise automated subset selection algorithms: Frequency of obtaining authentic and noise variables. British Journal of Mathematical and Statistical Psychology, 45(2), 265-282.

109) Kwah, L. K., & Diong, J. (2014). National Institutes of Health Stroke Scale (NIHSS). Journal of physiotherapy, 60(1), 61.

110) ICHOM Stroke Data Collection Reference Guide. http://www.ichom.org/download/stroke-reference-guide/. Accessed October 5, 2018.

111) Austin, P. C. (2011). An introduction to propensity score methods for reducing the effects of confounding in observational studies. Multivariate behavioral research, 46(3), 399-424.

Appendix 1: TRIPOD checklist for Prediction Model Development

TRIPOD Checklist: Prediction Model Development

Section/Topic	Item	Checklist Item	Page
Title and abstract			
Title	1	Identify the study as developing and/or validating a multivariable prediction model, the target population, and the outcome to be predicted.	First page
Abstract	2	Provide a summary of objectives, study design, setting, participants, sample size, predictors, outcome, statistical analysis, results, and conclusions.	i
Introduction			
Background and objectives	3a	Explain the medical context (including whether diagnostic or prognostic) and rationale for developing or validating the multivariable prediction model, including references to existing models.	11-15
	3b	Specify the objectives, including whether the study describes the development or validation of the model or both.	14-15
Methods			
Source of data	4a	Describe the study design or source of data (e.g., randomized trial, cohort, or registry data), separately for the development and validation data sets, if applicable.	32
	4b	Specify the key study dates, including start of accrual; end of accrual; and, if applicable, end of follow-up.	32
Participants	5a	Specify key elements of the study setting (e.g., primary care, secondary care, general population) including number and location of centres.	32
	5b	Describe eligibility criteria for participants.	32
	5c	Give details of treatments received, if relevant.	33-34
Outcome	6a	Clearly define the outcome that is predicted by the prediction model, including how and when assessed.	39
	6b	Report any actions to blind assessment of the outcome to be predicted.	N/A
Predictors	7a	Clearly define all predictors used in developing or validating the multivariable prediction model, including how and when they were measured.	34-39
	7b	Report any actions to blind assessment of predictors for the outcome and other predictors.	N/A
Sample size	8	Explain how the study size was arrived at.	39-40
Missing data	9	Describe how missing data were handled (e.g., complete-case analysis, single imputation, multiple imputation) with details of any imputation method.	39-40
Statistical analysis methods	10a	Describe how predictors were handled in the analyses.	41-42
	10b	Specify type of model, all model-building procedures (including any predictor selection), and method for internal validation.	41-44
	10d	Specify all measures used to assess model performance and, if relevant, to compare multiple models.	42-43
Risk groups	11	Provide details on how risk groups were created, if done.	N/A
Results			
Participants	13a	Describe the flow of participants through the study, including the number of participants with and without the outcome and, if applicable, a summary of the follow-up time. A diagram may be helpful.	46
	13b	Describe the characteristics of the participants (basic demographics, clinical features, available predictors), including the number of participants with missing data for predictors and outcome.	46-50
Model development	14a	Specify the number of participants and outcome events in each analysis.	46
	14b	If done, report the unadjusted association between each candidate predictor and outcome.	48-51
Model specification	15a	Present the full prediction model to allow predictions for individuals (i.e., all regression coefficients, and model intercept or baseline survival at a given time point).	54-55
	15b	Explain how to the use the prediction model.	59-60
Model performance	16	Report performance measures (with CIs) for the prediction model.	56-57
Discussion			
Limitations	18	Discuss any limitations of the study (such as nonrepresentative sample, few events per predictor, missing data).	69-71
Interpretation	19b	Give an overall interpretation of the results, considering objectives, limitations, and results from similar studies, and other relevant evidence.	61-68

Implications	20	Discuss the potential clinical use of the model and implications for future research.	71-73
Other information			
Supplementary information	21	Provide information about the availability of supplementary resources, such as study protocol, Web calculator, and data sets.	N/A
Funding	22	Give the source of funding and the role of the funders for the present study.	N/A

Appendix 2: Curriculum Vitae

Jerome Iruthayarajah

Education

MSc, Epidemiology and Biostatistics

University of Western Ontario, London, ON 2016/19

BSc, Honours Specialization in Neuroscience

University of Western Ontario, London, ON 2011/15

Peer reviewed Journal Publications

Iruthayarajah J, McIntyre A, Mirkowski M, Welch-West P, Loh E, Teasell R. Risk factors for dysphagia after a spinal cord injury: a systematic review and meta-analysis. Spinal Cord, 2018; 56: 1116-1123.

McIntyre A, Benton B, Janzen S, Iruthayarajah J, Wiener J, Eng JJ, Teasell R. A mapping review of randomized controlled trials in the spinal cord injury research literature. Spinal cord, 2018; 56: 725-732.

Cotoi A, Mirkowski M, Iruthayarajah J, Anderson R, Teasell R. The effect of theta-burst stimulation on unilateral spatial neglect following stroke: a systematic review. Clinical rehabilitation, 2018; 0269215518804018.

Iruthayarajah J, Alibrahim F, Mehta S, Janzen S, McIntyre A, Teasell, R. Cognitive behavioural therapy for aggression among individuals with moderate to severe acquired brain injury: a systematic review and meta-analysis. Brain injury, 2018; 32(12): 1443-1449.

Mehta S, McIntyre A, Janzen S, Iruthayarajah J, Bateman A, Teasell R. Pharmacological management of agitation among individuals with moderate to severe acquired brain injury: A systematic review. Brain injury, 2018; 1-10.

Mehta S, Janzen S, McIntyre A, Iruthayarajah J, Loh E, Teasell, R. Are Comorbid Pain and Depressive Symptoms Associated with Rehabilitation of Individuals with Spinal Cord Injury? Topics in Spinal Cord Injury Rehabilitation, 2017; 24(1), 68-79.

Iruthayarajah J, McIntyre A, Cotoi A, Macaluso S, Teasell R. The use of virtual reality for balance among individuals with chronic stroke: A systematic review and meta-analysis. Topics in Stroke Rehabilitation, 2016; 1-12.

Hebert D, Lindsay P, McIntyre A, Kirton A, Rumney P, Bagg S, Bayley M, Dowlatshahi D, Dukelow S, Garnhum M, Glasser E, Halabi M, Kang E, MacKay-Lyons M, Martino R, Rochette A, Rowe S,Salbach N, Semenko B, Stack B, Swinton L,Weber V, Meyer M, Verrilli S, DeVeber G, Andersen J, Barlow K, Cassidy C, Dilenge M, Fehlings D, Hung R, Iruthayarajah J, Lenz L, Majnemer A, Purtzki J, Rafay M, Sonnenberg L, Townley A, Janzen S, Foley N, Teasell R. Canadian stroke best practice recommendations: Stroke rehabilitation practice guidelines, update 2015. International Journal of Stroke: 11(4); 459-484.

Published Book Chapters

Fraser C, Iruthayarajah J, McIntyre A, Serrato J, Benton B, Teasell RW. (2016). Nutrition Issues Following Spinal Cord Injury. In Eng JJ, Teasell RW, Miller WC, Wolfe DL, Townson AF, Hsieh JTC, Noonan VK, Loh E, Sproule S, McIntyre A, Querée M, editors. Spinal Cord Injury Rehabilitation Evidence. Version 6.0: p 1-52.

Hsieh J, McIntyre A, Iruthayarajah J, Loh E, Ethans K, Mehta S, Wolfe D, Teasell R. (2014). Bladder Management Following Spinal Cord Injury. In Eng JJ, Teasell RW, Miller WC, Wolfe DL, Townson AF, Hsieh JTC, Connolly SJ, Noonan VK, Loh E, McIntyre A, editors. Spinal Cord Injury Rehabilitation Evidence. Version 5.0: p 1-196.

Published Abstracts

Iruthayarajah J, McIntyre A, Janzen S, Teasell R. Functional Gain and Societal Reintegration After a Stroke: Evidence From Home-Based Outpatient Rehabilitation. Archives of Physical Medicine and Rehabilitation 2017; 98(12), e168.

Wiener J, Mehta S, Iruthayarajah J, Janssen S, Teasell R. The Effectiveness of Cognitive Behavioural Therapy for The Management of Post-Stroke Depressive Symptoms. Archives of Physical Medicine and Rehabilitation 2017; 98 10), e137.

Iruthayarajah J, McIntyre A, Cotoi A, Macaluso S, Teasell R. The use of virtual reality for balance among individuals with chronic stroke: A systematic review and meta-analysis. European Stroke Journal 2016.

Janzen S, McIntyre A, Iruthayarajah J, Vermeer J, Britt E, Teasell R. A knowledge translation initiative: Examining the sustainability of change on a stroke rehabilitation unit. European Stroke Journal 2016.

Brar J, McIntyre A, Cotoi A, Jinah A, Iruthayarajah J, Vermeer J, Teasell R. Efficacy of playing musical instruments for upper limb rehabilitation among individuals with stroke: A systematic review. Archives of Physical Medicine and Rehabilitation 2016; 97(10): e144.

Cotoi A, Iruthayarajah J, McIntyre A. "The Effect of Continuous Theta Burst Stimulation (Ctbs) on Unilateral Neglect in Patients with Stroke: A Systematic Review." Archives of Physical Medicine and Rehabilitation 2016; 97(10): e144.

Sequeira N, Janzen S, Iruthayarajah J, McIntyre A, Teasell R. Effectiveness of Phenytoin and Levetiracetam for seizure prophylaxis among a traumatic brain injury population: A systematic review. Archives of Physical Medicine and Rehabilitation 2016; 97(10): e144.

Mehta S, Janzen S, McIntyre A, Iruthayarajah J, Loh E, Teasell R. Does the Presence of Comorbid Pain and Depression Symptoms Effect the Rehabilitation of Individuals with Spinal Cord Injury? Archives of Physical Medicine and Rehabilitation 2016; 97(10): e60.

Mehta S, McIntyre A, Janzen S, Iruthayarajah J, Bateman A, Teasell R. Pharmacological management of agitation among individuals with moderate to severe acquired brain injury: A systematic review. Archives of Physical Medicine and Rehabilitation 2016; 97(10): e144.

Vermeer J, McIntyre A, Iruthayarajah J, Janzen S, Benton B, Teasell R. The Efficacy of Rhythmic Auditory Stimulation for Improving Motor Function After a Stroke: A Systematic Review. Stroke congress

Vermeer J, Iruthayarajah J, Janzen S, McIntyre A, Viana R, Macaluso S, Teasell R. Current Trends in Motor Rehabilitation Interventions among the Chronic Stroke Population. Stroke congress

McIntyre A, Janzen S, Iruthayarajah J, Rice D, Eng JJ, Teasell R. Randomized controlled trials in spinal cord injury have good methodological quality but are underpowered. Topics in Spinal Cord Injury 2014;20(supplement 1):62.

McIntyre A, Janzen S, Rice D, Iruthayarajah J, Eng JJ, Teasell R. The landscape of spinal cord injury randomized controlled trials. Topics in Spinal Cord Injury 2014;20(supplement 1):67.

Scholarly and Professional Activities

Manuscript peer reviewer for the journals:

Spinal Cord

European Journal of Physical and Rehabilitation Medicine

Topics in Stroke Rehabilitation

Transactions on Accessible Computing

Graduate Teaching Assistant

University of Western Ontario, Epidemiology and Biostatistics

Academic Awards/Funding

London Life Stroke Rehabilitation Studentship ($36,852) – 2017/2018

Western Graduate Research Scholarship ($4,200) – 2017/2018

London Life Stroke Rehabilitation Studentship ($36,740) – 2016/2017

Western Graduate Research Scholarship ($4,200) – 2016/2017

Queen’s Aiming for the Top Scholarship ($3,500) – 2012/2013

Queen’s Aiming for the top Scholarship ($3,500) – 2011/2012

Western University Entrance Scholarship ($2,000) – 2011