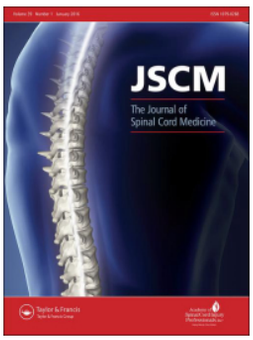

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Research Article

Development of Reaching, Grasping & Manipulation indicators to advance the quality of spinal cord injury rehabilitation: SCI-High Project

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Objective: To describe the development of structure, process, and outcome indicators aimed to advance the quality of Reaching, Grasping & Manipulation (RG&M) rehabilitation for Canadians living with spinal cord injury or disease (SCI/D).

Method: Upper extremity rehabilitation experts developed a framework of indicators for evaluation of RG&M rehabilitation quality. A systematic search of the literature identified potential upper extremity indicators that influence RG&M outcomes. A Driver diagram summarized factors influencing upper extremity outcomes to inform the selection of *structure* and *process* indicators. Psychometric properties, clinical utility, and feasibility of potential upper extremity measures were considered when selecting *outcome* indicators.

Results: The selected structure indicator is the number of occupational and physical therapists with specialized certification, education, training and/or work experience in upper extremity therapy related to RG&M at a given SCI/D rehabilitation center. The process indicator is the total hours of upper extremity therapies related to RG&M and the proportion of this time allocated to neurorestorative therapy for each individual with tetraplegia receiving therapy. The outcome indicators are the Graded Redefined Assessment of Strength, Sensation and Prehension (GRASSP) strength and Spinal Cord Independence Measure III (SCIM III) Self-Care subscores implemented at rehabilitation admission and discharge, and SCIM III Self-Care subscore only at 18 months post-admission.

Conclusion: The selected indicators align with current practice, will direct the timing of routine assessments, and enhance the volume and quality of RG&M therapy delivered, with the aim to

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ultimately increase the proportion of individuals with tetraplegia achieving improved upper extremity function by 18 months post-rehabilitation.

Keywords: Health care, Outcome assessment, Physical functional performance, Quality indicators, Rehabilitation, Tetraplegia, Upper extremity

Introduction

Individuals living with tetraplegia prioritize regaining and enhancing their upper extremity function during rehabilitation in order to: increase their functional abilities; reduce their lifetime burden of care; and, enhance their quality of life.[1] In addition, a significant and rising proportion of individuals with non-traumatic spinal cord injury (ntSCI)[2] present with tetraplegia[1] and associated declines in upper extremity function.[3,4] The most common etiology of ntSCI resulting in tetraplegia/paresis in Canada include: degenerative diseases, infection, tumors and vascular disease.[5] Considering the changing demographic of spinal cord injury (SCI) in Canada[6,7] (rising incidence of ntSCI) and the proportion of individuals with tetraplegia or tetra-paresis, restoration of upper extremity function is a domain of rising importance for individuals with traumatic (tSCI) and ntSCI requiring rehabilitation. The known incidence as of 2010 for tSCI and ntSCI in Canada is 41 per million and 68 per million respectively, for a total of 4,071 per annum. In 2010, the prevalence was estimated to be 85,556 persons in Canada, with 51% tSCI and 49% ntSCI. This estimate is conservative as it is derived from the number of inpatients receiving surgical intervention; therefore, the numbers of ntSCI are likely much higher.[7]

For service providers and administrators, it is important to recognize that not only is the restoration of upper extremity function essential to individuals with SCI and disease (SCI/D), it is a significant component of the volume of the rehabilitation routinely delivered. High-quality rehabilitation care following SCI/D is critical for optimizing neurorecovery, functional restoration, and long-term health outcomes. Currently, there are no evidence-informed guidelines that specify the type and volume of upper extremity therapy to optimize outcome.

Enhancing the delivery of rehabilitation care specific to the upper extremity among individuals with tetraplegia requires therapy to optimize neurorecovery,[8] preventive interventions to limit upper extremity injury/overuse or deformity,[9] and enhanced community outcomes post-discharge.[10] Quality indicators are intended to be feasible for implementation within a tertiary SCI rehabilitation program serving individuals with tetraplegia regardless of injury etiology. This manuscript focuses on establishing a framework of quality indicators to assess rehabilitation specific to the upper extremity function for individuals living with tetraplegia using a methodical approach, available evidence, and expert consensus. To begin this process, we must first understand the current state of rehabilitation delivery, the extent to which the population benefits from rehabilitation therapy, and the natural history of recovery.

Current state of upper extremity, motor and sensory rehabilitation

As a field, we recognize some sensory and motor gains occur after tSCI and ntSCI. The extent of these gains are modulated by the location, completeness, and severity of lesion.[11] There are some detailed demonstrations of these recovery curves defining the spatial and temporal recovery of individuals according to their baseline American Spinal Injury Association Impairment Scale (AIS) categories over 12 months.[12–15] Beyond the first year, we are certain there is ongoing recovery up to 24 months after injury;[16] however, the second year is not as well described in the literature.[13,17] Further, much of the development of intensive therapeutic protocols has been conducted among individuals with chronic tetraplegia, inferring this group has potential to make gains.[8,18–23] Assuming that spontaneous recovery occurs during inpatient and outpatient tertiary SCI rehabilitation, it is essential to have indicators to capture how the provision of upper extremity therapies influence or optimize: spontaneous recovery, facilitate functional adaptations, and the long-term ability of individuals with tetraplegia to reach, grasp and manipulate objects in their environment.

Indicators can measure the structure, process or outcome of health care services, and their evaluation can facilitate the sustainability of a high-quality health care delivery system that is based on evidence-informed programs and services.[24] *Structure indicators* are defined by the properties of the setting in which the health care services occur[25] while *process indicators* describe the specific activities in providing and receiving care.[26] Finally, *outcome indicators* evaluate health changes that can be attributed to the health care or therapy provided, such as mortality, health-related quality of life, individual/family/provider satisfaction, and functional ability.[26] Indicator data can inform

comparisons across different health care settings and systems to ensure continuous quality improvement and the establishment of benchmarks for superior organizations.[27,28] This manuscript describes the context and approach to developing the Reaching, Grasping & Manipulation (RG&M) indicators for application during the first 18 months after SCI/D rehabilitation admission. This is part of the work developed by the SCI-High Project (www.sci-high.ca) aiming to select, implement, and evaluate quality care indicators for 11 domains of SCI rehabilitation in Canada by 2022. The RG&M Working Group's objective was to establish a comprehensive framework of structure, process, and outcome indicators specific to the Domain construct of RG&M for implementation in Canada.

Methods

A detailed description of the processes for identifying RG&M as a priority Domain for SCI/D rehabilitation care and the overall SCI-High Project methods have been previously described.[29,30] In brief, the approach to developing the structure, process, and outcome indicators for the RG&M Domain followed a modified, but substantially similar, approach to that described by Mainz *et al.*,[27] including: (a) formation and organization of the national and local Working Groups; (b) defining and refining the domain aim and specific target construct; (c) providing an overview or summary of existing evidence and practice; (d) developing and interpreting a Driver diagram; (e) selecting indicators; and (f) pilot testing and refinement of the domain-specific structure, process and outcome indicators prior to implementation. A facilitated discussion occurred amongst the Domain-specific Working Group and the SCI-High Project Team to utilize relevant expertise on the topic while ensuring the broader goals of the SCI-High Project were aligned across the other ten Domain Working Groups. Stakeholders and experts were invited to participate in RG&M Working Group based on their practical or empirical knowledge of SCI/D rehabilitation, reaching, grasping and manipulation, and individual care. The group was composed of occupational therapists (OTs), physical therapists (PTs), physiatrists, rehabilitation scientists, and postdoctoral fellows. Five videoconference meetings of the RG&M Working Group were held between March 2016 and June 2016, totaling five hours of discussion. We also met for additional five hours from Aug 2020–Jan 2021, to refine the indicators and complete manuscript preparation. In addition, individual members of the Working Group completed their own independent review of the prepared materials, and shared resources and/or practice standards with one another outside of the formally scheduled meetings.

The Working Group was asked to develop/select at least one structure, process, and outcome indicator related to the RG&M Domain. The SCI-High Project Team stipulated that the indicators must be relevant, concise (10 min or less to implement), and aligned in their aim across the structure, process, and outcome indicators to achieve a single substantive advance in SCI/D rehabilitation care. The indicators could be measured using established or new measurement tools (i.e. questionnaires, data collection sheets, laboratory exams, and medical record data), depending on the requirements and feasibility considerations specific to each indicator.

Domain-specific working group meetings

The meetings of the RG&M Working Group were organized to frame the context for clinical practice using an "eliminate and concentrate" decision-making approach to review the key constructs related to RG&M, review available outcome indicators, and develop an evidence-informed Driver diagram to establish indicators of the quality of upper extremity rehabilitation for implementation from rehabilitation admission to 18 months thereafter. Initially, the Working Group used a comprehensive mixed method that combined scientific evidence and expert consensus for developing a construct definition for RG&M. A small number of fundamental and strategically important indicators were deemed feasible via group consensus to collect at a clinical level. The development of the activities classification tool for the process indicator and the timelines for implementing the indicators was established through iterative consensus.

Literature search

Two members of the Project Team independently (MA, MO) conducted a systematic search of the literature using MEDLINE, CINAHL and EMBASE while applying a combination of the MeSH terms: "spinal cord injury", "strength/ or hand/ or hand function", "reaching", "grip", and "grasping". The search focused on potential outcome indicators for RG&M and the factors that influence RG&M outcomes in SCI/D rehabilitation. Inappropriate references were excluded (i.e. non-English, theses, conference abstracts, qualitative research).

Driver diagram

Following the literature search, the challenge of selecting quality indicators was facilitated by creating an

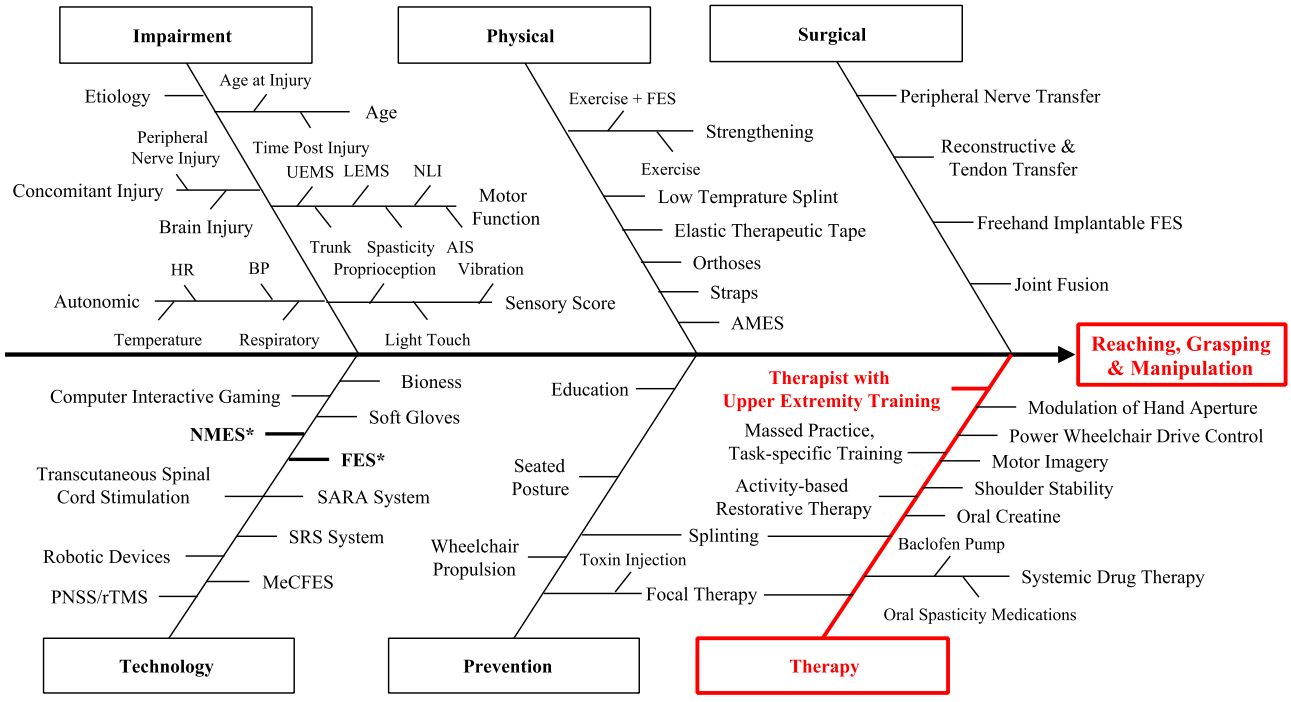

Figure 1 Driver diagram for the RG&M Domain. The Impairment Branch is common to all 11 SCI-High Domains. The red items shown in the diagram represent the aim of the indicators. *Thicker black lines on the Technology branch reflect the greater volume of evidence supporting NMES and FES. *UEMS: Upper-Extremity Motor Score, LEMS: Lower-Extremity Motor Score, NLI: Neurological Level of Injury, AIS: ASIA Impairment Scale, HR: Heart Rate, BP: Blood Pressure; FES: Functional Electrical Stimulation, AMES: Assisted Movement with Enhanced Sensation, Bioness Inc., NMES: Neuromuscular Electrical Stimulation, SARA System: Smart Assistive Reacher Arm (SARA) System, SRS System: Stimulus Router System, MeCFES: Myoelectrical Controlled Functional Electrical Stimulation, and PNSS/rTMS: Peripheral Nerve Somatosensory Stimulation System/repetitive Transcranial Magnetic Stimulation.*

Ishikawa (fishbone) or Driver diagram.[31] As part of the analysis, a graphic illustration was constructed to convey the relationships between SCI/D rehabilitation care related to upper extremity and factors that influence RG&M outcomes. Following the review of the literature, the RG&M Working Group engaged in a mind-mapping exercise to identify the factors that affect upper extremity rehabilitation. The identified factors were grouped into categories or branches (Figure 1). Guided by the Driver diagram using RAND/UCLA[32] methodology, the RG&M Working Group proposed structure, process, and outcome (intermediary and final) indicators. These well-established outcomes have had appropriate psychometric properties (i.e. reliability, validity, and responsiveness) for use in SCI/D populations.[33–37]

Results

Construct definition and aim

The Working Group considered the scope and breadth of the upper extremity in healthy populations as well as in individuals with sensorimotor impairments when formulating this construct:[38]

> *Reaching, grasping and manipulation are the important components of upper extremity function that allow individuals with tetraplegia (C1-T1, AIS A-D) to use the sensorimotor integrity of their arm and hand to develop abilities and perform activities that meet their personal needs, and enable them to explore and participate in their external environment in meaningful ways.*

The aim of the RG&M Domain is to implement standardized routine testing of arm and hand function among individuals with tetraplegia in order to: optimize upper extremity neuro-recovery and functional ability, and to understand the associations between specificity, volume, and intensity of therapy delivery and individual outcome.

Driver diagram

The outcomes of the systematic search guided the constructions of the RG&M Driver diagram (Figure 1), which focused on physical, surgery, preventive, technology, prevention and therapy related to RG&M rehabilitation care delivery. The Driver diagram reflects the dichotomy within SCI/D rehabilitation, where

Table 1 Description of the therapeutic constructs underlining the RG&M practices which informed indicator development.

Prevention Therapy Concept
Prevention of injury or complications focuses on regional trauma, joint deformity, co-contractions, muscle imbalance, spasticity, contracture, shoulder subluxation, shoulder elbow or wrist overuse injury, overstretching of the finger flexor tendons and hyperextension of the metacarpophalangeal joints.
Optimizing seating stability focuses on selecting the most appropriate, ergonomic wheelchair and seating system; promoting an optimal seated posture and stabilization for trunk stability and upper extremity needs; optimizing techniques and performance during wheelchair propulsion and related skills (e.g. pressure relief, transfers); and functional activities.
Neurorestorative Therapy Concept
Neurorestoration is a process to promote, restore, or maintain the integrity of the neurological functions by using neurorestorative strategies, including physical, chemical, biological, and surgical interventions, or any other kinds of intervention that bring about structural and/or functional restoration simultaneously.[75] Functional recovery is the typical objective of neurorestorative therapies. Neurorestorative therapies in the context of the RG&M Domain will focus on restoring, promoting, or maintaining the sensorimotor integrity of the upper extremity which has been compromised secondary to the traumatized/diseased spinal cord by employing therapeutic techniques that may improve joint range of motion, strength and/or coordination to allow for progression with activity-based therapies with the ultimate goal of maximizing functional recovery.

therapy encompasses attempts at restoration of lost function and teaches compensatory strategies to minimize impairment(s) and augment functional ability. The goals of prevention treatment practices are shown in Table 1.

Following group discussions and considering the existing knowledge of what occurs in rehabilitation, and the natural history and severity of the disease, the Working Group decided to focus the indicators on therapy delivery.

Structure indicator

The selected structure indicator reflects the delivery of upper extremity rehabilitation in North America. As shown in the training, technology, prevention, physical, and therapy arms of the Driver diagram, upper extremity therapy consists of a diverse group of interventions. Interventions with the greatest support for their efficacy[39] include: task-specific training; repetitive practice of isolated and integrated functional movements of the shoulder elbow, wrist and hand with or without the application of technology (including Neuromuscular Electrical Stimulation (NMES), and Functional Electrical Stimulation (FES))[39] and provision of surgical interventions, including tenodesis or peripheral nerve transplant.[40,41] For the purpose of this manuscript, NMES refers to as the application of an electrical current of sufficient intensity to elicit or facilitate muscle contraction (i.e. sensorimotor impairments targeted). FES refers to the pairing of NMES, simultaneously or intermittently, to facilitate or allow the performance of a functional task, such as arm cycling or grasping (i.e. functional disability targeted). As the current literature does not strongly favor one form of intervention over another in the subacute rehabilitation setting,[39] the Working Group chose description of OT and PT expertise as the key construct underpinning the structure indicator. The selected structure indicator is the number of OTs and PTs at a given site with five or more years of experience in upper extremity rehabilitation related to the SCI/D population *or* education, training/certification in upper extremity therapy not obtained through their entry-level professional academic degree, relative to the number of OTs and PTs providing care to individuals with SCI/D at each site per fiscal year. The structure indicator will be assessed using the tool shown in Figure 2.

Process indicator

Given that gains in upper extremity function are dependent on the amount of integrated practice and may be dose- and activity-dependent, and require specific technologies, the process indicator is the total number of upper extremity hours of therapy received during their rehabilitation length of stay and the proportion of time allocated to neurorestorative therapy. OTs and PTs will enter the total number of minutes per therapy session per day spent on upper extremity therapy as part of their daily workload documentation. The sum of the total minutes of upper extremity therapy will be calculated (sum of training minutes) for each individual with tetraplegia who meets the requirements for provision of upper extremity therapy during the admission International Standards for Neurological Classification of SCI (ISNCSCI) assessment (individuals with tetraplegia C1 -T1 AIS A-D tetraplegia with voluntary motor function in at least one C5-T1 myotome regardless of cord syndrome). Figure 3 summarizes activities directly or indirectly related to RG&M therapy delivered by OTs and PTs during SCI/D rehabilitation. In addition, the therapist will then be asked to estimate the proportion of time each day allocated to neurorestorative therapy.

This tool should be filled out by all inpatient and outpatient Occupational and Physical Therapists (full-time, part-time, and casual) participating in the provision of Reaching, Grasping & Manipulation therapy services for patients with spinal cord injury or disease (SCI/D) in your organization. We anticipate this will take approximately 6-8 minutes to complete. The information collected will be used to inform the quality of rehabilitation care for individuals with SCI/D.

1. Date: ____/____/____ (YY/ MM/DD)
2. Please provide your initials: _____
3. Please identify your parent organization: _____
4. Please identify your profession:
   - ○ Occupational Therapist
   - ○ Physical Therapist

   Other: _____
5. Please identify your type of employment:
   - ○ Full-time
   - ○ Part-time
     - ○ 1 day/week
     - ○ 2 days/week
     - ○ 3 days/week
     - ○ 4 days/week
   - ○ Casual
6. Please identify your gender:
   - ○ Male
   - ○ Female
   - ○ Other
   - ○ Prefer not to disclose

Work Experience:

7. How many years (or months) of work experience related to SCI/D do you have? _____Year(s) _____Month(s)
8. On average, for how many SCI/D patients did you provide reaching, grasping & manipulation therapy services within the last 3 months?

Training and Certification:

9. Have you taken a Bobath SCI course? Yes No
10. If yes to question 9, please provide the course name:_____
11. Have you taken a MyndMove™ therapy training course? Yes No
12. If yes to question 11, please provide the course name:_____
13. Have you taken a GRASSP training course? Yes No
14. If yes to question 13, please provide the course name:_____
15. Have you taken a course focused on functional electrical stimulation (FES) related to reaching, grasping & manipulation therapy? Yes No
16. If yes to question 15, please provide the course name:_____
17. Have you taken a course focused on neuromuscular electrical stimulation (NMES) related to reaching, grasping & manipulation therapy? Yes No
18. If yes to question 17, please provide the course name:_____
19. Have you taken any other evidence-based training program or course related to reaching, grasping & manipulation therapy? Yes No
20. If yes to question 19, please provide the course name:_____
21. Have you attended a practical reaching, grasping & manipulation therapy training workshop and/or information session during the last year? Yes No
22. If yes to question 21, please describe:_____
23. During the last year, have you completed an online educational and training module related to reaching, grasping & manipulation therapy training? Yes No
24. If yes to question 23, please describe:_____
25. During the last year, have you participated in an informal reaching, grasping & manipulation therapy-related training offered by vendors? Yes No
26. If yes to question 25, please describe:_____

Knowledge Maintenance:

27. Do you participate in journal clubs and/or publication reviews related to reaching, grasping & manipulation therapy training? Yes No
28. Have you attended any conferences related to reaching, grasping & manipulation therapy training in the last year? Yes No
29. If yes to question 28, name of conference(s):_____
30. Do you have access to mentors or peers with expertise in reaching, grasping & manipulation therapy training in SCI/D? Yes No
31. If yes to question 30, onsite or by phone/video/email? _____

Figure 2 RG&M structure indicator tool.

Reaching, Grasping & Manipulation activities	
Assistive technology	Skin management
Balance & ambulation exercises/strategies	Spinal stimulation*
Bathing	Splint/cast fabrication & use
Bed mobility	Standing frame/tilt table
Bed mobility/positioning	Strengthening/endurance exercises*
Bladder management	- Basic/low-tech equipment
Bowel management	- Gym machines
Clothing management and hygiene for toileting	- Manual resistance
Communication (read, write, phone use)	- Neuromuscular re-education
Don/doff adaptive equipment	- Overhead slings/mobile arm support
Driving	- Strengthening/no equipment
Feeding	Stretching/ROM exercises*
FES*	Therapeutic activities*
Grooming	- Fine motor activities
Home management skills (meal prep, laundry)	- Tenodesis training
Lower body dressing	- Manual therapy
Medication management	- Edema management
Modalities (paraffin, wax, k-tape, coban, heat)	- Visual/perceptual training
NMES*	- Desensitization
Participation sport	Transfers
Pressure-relieving - lean/offload side to side	Upper body dressing
Robotics*	Wheelchair mobility-manual
Skin checks (with inspection mirror)	Wheelchair mobility-power (hand control)
TOTAL MINUTES PER/SESSION/PATIENT	
PROPORTION OF THE ABOVE TIME ALLOCATED TO NEURORESTORATIVE THERAPY	

**Neurorestorative therapies.*

Figure 3 Alphabetical list of therapeutic activities intended to facilitate Reaching, Grasping & Manipulation outcomes. This table was modified from Ozelie et al., 2012[73] with feedback from Lyndhurst Centre OTs and PTs and RG&M Working Group Members.

Integral to the accurate reporting of this process indicator is a clear guideline of what therapeutic interventions constitute upper extremity interventions (Table 1). The RG&M Group agreed upon two criteria for therapists to consider when determining whether a therapeutic activity could count as part of the process of upper extremity therapy. First, the therapeutic activity involves whole-or part-practice of a functional goal or use of skills-focused training in activity-based interventions or, second, the therapeutic activity had a neurorestorative emphasis to facilitate gains in upper extremity sensorimotor function.

Outcome indicator

The systematic search of outcomes highlighted a variety of outcome measurement tools related to upper extremity function, which are summarized in Table 2. The selected outcome indicators are the Graded Redefined Assessment of Strength, Sensation and Prehension (GRASSP) strength and the Spinal Cord Independence Measure III (SCIM III) Self-Care subscores implemented at rehabilitation admission and discharge, and SCIM III Self-Care subscore only at 18 months post-admission. The criterion for the selection of outcome indicators were: feasibility for implementation; robustly studied with sound psychometric properties in SCI/D. The choice of outcomes was predicated upon the established Rick Hansen SCI Registry (RHSCIR) practice of measuring ISNCSCI motor scores and SCIM scores at rehabilitation admission and the correlation of the recovery rate with the duration of follow-up ($p=0.001$) observed in a recent

Table 2 Systematic search of outcomes related to reaching, grasping and manipulation.

Measurement Tool	Scale
Functional Independence Measure (FIM)[76,77]	Number of Items = 18, 13 motor and 5 socio-cognitive subscales, scored from 1 (total dependence) to 7 (total independence)
Graded Redefined Assessment of Strength, Sensibility and Prehension (GRASSP)[36]	Sensation: Number of Items = 3 locations for dorsal and 3 locations for palmar side of each hand-scored from 0 to 4 Strength: Number of Items = 10 arm & hand muscle for each arm scored from 0 to 5 Prehension: Number of Items = 3 grasping, 6 prehension tasks for each arm divided to prehension ability subscale scored from 0 to 4 and prehension performance subscale scored from 0 to 5
Grasp Release Test (GRT)[78,79]	Number of Items = 6, Subjects grasp, move and release six different objects as many times as possible in three 30-s trials for each object. Three objects have to be manipulated with palmar grasp and three objects with lateral grasp. The number of attempts, completions and failures are registered.
Quadriplegia Index of Function (QIF)[80]	Number of Items = 37, the functional performance categories are scored on a 5-point scale from 0 (dependent) to 4 (independent)
Spinal Cord Independence Measure (SCIM)[62,81]	Number of Items = 19, Item response categories vary from item to item; ranging from 0–2 to 0-15, Scores are derived by adding up the items producing a total score (0 to 100) and/or subscale scores (self-care: 0-20; respiration and sphincter management: 0-40; mobility 0-40)
Toronto Rehabilitation Institute Hand Function Test (TRI-HFT)[82]	Number of Items = 14, 10 manipulation items, using palmar and lateral pinch grasp scored from 1 to 7, where each item is scored in each of the 3 positions except the mug and the zip lock bag which are not scored in supination. 4 Strength Items, using items with dynamometers to measure lateral grip force and circular grip force, Strength test is scored using Newtons
The Van Lieshout Test Short Version (VLT-SV)[83,84]	Number of Items = 10, scored on a 6-point scale from 0 (task was not possible) to 5 (highest level of accomplishment), Individual item scores take into account the 1) ability to complete the task; 2) behavioral quality of performance (e.g./accuracy of task completion); and 3) independence in performing the task without using external support (e.g./assistance of the contralateral arm)

systematic review and meta-analysis.[42] Studies with follow-up duration of approximately six months or less reported significantly lower recovery rates for incomplete SCI compared to studies with long-term follow-up. The RG&M working group anticipated that hours of activity-based therapies would result in measurable improvement in SCIM III Self-Care subscores and that neurorestorative therapies would be reflected in GRASSP strength subscores.

Table 3 summarizes the structure, process and outcome indicators or the RG&M Domain.

Discussion

This SCI-High Project manuscript is part of a concerted effort to identify priority indicators of quality care for SCI/D rehabilitation that can be readily incorporated into usual clinical care. The manuscript describes and defines a framework of structure, process, and outcome indicators for implementation during upper extremity rehabilitation among individuals with tetraplegia during inpatient rehabilitation and post-discharge in the community. Indicator development incorporated the engagement of an expert Working Group, systematic search and synthesis, Driver diagram development, and the selection of indicators was based on evidence and expert consensus. Indicator selection was guided by the widely documented limitations of resources in terms of infrastructure, time and personnel.[43,44] The selected indicators will provide crucial information regarding rehabilitation intensity and specifications, and associated RG&M outcomes. The data will inform the future creation of benchmarks[45] for optimal and equitable upper extremity rehabilitation post-SCI. Further, this indicator data, once prospectively collected, will help the field to better understand how the existing rehabilitation services across Canada can optimize upper extremity function in individuals with tetraplegia by elucidating the recovery profiles and the role of rehabilitation in maximizing upper extremity functional restoration.

Structure indicator

The structure indicator will be the number of OTs and PTs with specialized certification, education, training and/or work experience in upper extremity intervention and therapy related to RG&M relative to the number of

Table 3 Minimal data set of reaching, grasping and manipulation indicators.

Indicator	Denominator	Type	Measurement
Number of OTs and PTs with specialized certification, education, training and/or work experience in upper extremity intervention and therapy related to RG&M	Total number of therapists participating in upper extremity therapy service provision at each site per FY*	Structure	Annual
Total hours of received upper extremity therapies related to RG&M and the proportion of this time (in hours) allocated to neurorestorative therapy during the rehabilitation length of stay	Number of individuals with tetraplegia**	Process	Rehabilitation discharge
GRASSP Strength Subscore	Number of individuals with tetraplegia**	Outcome - Baseline	Rehabilitation admission +/−72 weekday hours
SCIM Self-Care subscore (patient interview)	Number of individuals with tetraplegia**	Outcome - Baseline	Rehabilitation admission+/−72 weekday hours
GRASSP Strength Subscore	Number of individuals with tetraplegia**	Outcome - Intermediary	Rehabilitation discharge
SCIM Self-Care subscore (patient interview)	Number of individuals with tetraplegia**	Outcome - Intermediary	Prior to rehab discharge
SCIM Self-Care subscore (patient interview)	Number of individuals with tetraplegia**	Outcome - Final	18 months post-rehab admission

*FY: fiscal year; GRASSP: Graded Redefined Assessment of Strength, Sensation and Prehension measure; SCIM: Spinal Cord Independence Measure; AIS: American Spinal Injury Association Impairment Scale. **Individuals living with injuries or disease with a neurological level of injury between C1-T1 and AIS category between A-D and who received RG&M therapy. Implementation considerations: The structure indicator is collected annually at each participating site; the process indicator is collected daily for each individual receiving RG&M therapies; 3) the outcome indicators are captured at baseline, rehabilitation discharge, and 18-months post-rehabilitation admission. Baseline assessment should occur within seven days of admission to inpatient rehabilitation.

OTs and PTs providing upper extremity therapy to individuals with SCI/D per site per fiscal year.[46,47] The field of upper extremity rehabilitation for individuals with tetraplegia has gained significant momentum in the past 2–3 decades, specifically from a technology perspective[48] with increased research in robotics and FES. With newer rehabilitation techniques being evaluated, institutional best practices are evolving and vary across different rehabilitation settings in Canada.[49] Therapist skill and willingness to embrace evidence-based practice are amongst the many provider factors attributed to individual outcomes following rehabilitation.[50,51] However, the limitations to adoption of evidence-based practice are well documented and include lack of understanding and consensus of the meaning of evidence-based practice,[52] lack of time, support and/or resources to research literature, lack of knowledge and skills to assess research findings,[53] and difficulty in managing the process of translating evidence to practice.[54] For these reasons, and to ensure clinical feasibility of the indicators, we must capture the structure indicator within the context of institutional best practices and their influence on process and outcome indicators with minimal manipulation of therapy delivery. The goal of the current quality improvement project is to understand and highlight the positive or negative association between therapy delivery and RG&M individual outcomes hoping that it will set a tone for healthcare policy discussions and assist with continuing education efforts.

Process indicator

The process indicator will be the total number of hours of therapy directed towards retraining upper extremity function. Whereas these hours are more easily identified in OT and PT practices, we will miss those hours spent with the Physical and Occupational Therapy Assistants, and hence global understanding of therapy delivery will not be complete. The process indicators have value in understanding the relationship between intensity of therapy, the proportion of therapy time allocated to neurorestorative therapy, and individual functional outcomes. There is mixed evidence related to the benefit of increased therapy intensity on functional outcomes.[55–57] Although the selected indicators do not capture specific upper extremity rehabilitation techniques used, the literature supports that rehabilitation goals vary based on level and severity of SCI/D,[58,59] and techniques will vary based on therapist evaluations and therapist training, individual clinician biases

towards specific interventions,[60] and the individual's ability to participate in therapy without service interruptions due to concomitant health conditions (e.g. orthostatic hypotension, urinary tract infections, pressure injury, etc). Thus, this gives us an opportunity to study the outcome indicators in "real world" settings. The Working Group anticipated that an understanding of the activities and the volume of therapy will provide insights into individual outcomes.

Outcome indicator

The baseline, intermediary, and final outcome indicators (SCIM Self-Care subscores and GRASSP strength) are commonly used in the SCI/D population and time-effective.[3,15,35,61–63] The SCIM, a well-accepted measure given its psychometric properties is commonly used to describe for individual self-report of disease among individuals with SCI/D; and the fact that an interview format is being used improves the likelihood of collecting data at the 18 months follow-up time point, which is often considered challenging in quality improvement and research trials. The GRASSP consists of five subtests that characterize sensorimotor hand function. Of the subtests, GRASSP strength is the most reliable, precise and responsive. GRASSP strength also plays a significant role in predicting hand function as it relates to prehension.[34,64] The GRASSP strength subscore is reported to be the strongest predictor for upper extremity function and self-care outcomes.[15,65,66] Hence, we expect that the implementation of outcome indicators at baseline and both intermediary and final time points will be feasible.[67]

Application and use

Successful implementation of the structure, process, and outcome indicators will have a multi-level impact on the delivery of RG&M care and individuals living with tetraplegia. At the policy level, it will allow us to study the impact of resources: staffing, length of stay, capital resources for rehabilitation equipment, and resources for improving evidence-based practices, to name a few. At the site-specific level, it will provide insight into quality of care and how it stands against national benchmarks. At the practice level, it will help answer the very important question of therapy intensity and its relationship with long-term functional outcomes. If, in fact, we find a strong correlation across the three indicators, then the specific therapeutic maneuvers used might become less relevant, or alternatively, we might find that therapist expertise is more critical to better recovery profiles, or that more intense therapy irrespective of therapist level of expertise produces better outcomes. These hypotheses are speculative in nature, and in-depth analysis of the planned indicator data may provide new insights into which parameters modify quality of care. In any case, at the client level, it will help to improve best practices. Currently, the only data available is changes in the Functional Independence Measure (FIM), the length of stay, and the FIM efficiency which is the change in FIM divided by the length of stay. We need more SCI/D-specific measures that allow us to study recovery profiles over a longer-term. At this juncture, we have limited data regarding outpatient therapy provision, and functional gains or deterioration following rehabilitation discharge.[68] We also have to take into consideration that there may be an overlap between the indicator data collected for other Domains of rehabilitation care such as Walking[69] and Wheeled Mobility,[70] within the SCI-High Project. The risk with the proposed indicators is that there is a potential for double counting of interventions that can be substantially reduced with a detailed implementation plan and significant staff training for appropriate workload reporting.

Based on what is known about the natural history of motor recovery, a majority of inpatients are discharged at a time point when the slope of their recovery is greatest (Figure 4), suggesting that we may be missing an important therapeutic window.[71]

The RG&M Domain indicators have great potential to advance the field and provide new insights that are not

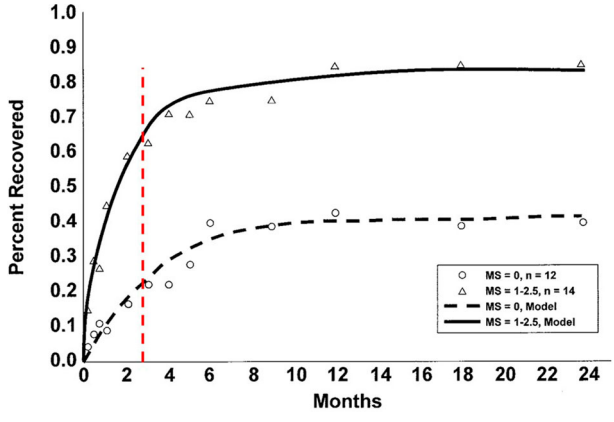

Figure 4 Illustration of the intersection between rehabilitation discharge (red vertical line) and the slope of change in upper extremity motor scores (MS). The red dotted line represents the median rehabilitation length of stay in Canada.[74] The recovery timeline graph was adapted from Burns and Ditunno, 2001,[71] displaying functional motor recovery in individuals with C6 tetraplegia with an initial MS at the C5 myotome. Solid and dotted black lines depict modeled data resulting from individuals with different motor scores.

currently available in public datasets, and may contribute to identifying responders and non-responders to specific types of interventions, thereby enhancing individuals' outcomes. The routine collection of the selected indicators will enable the field to understand "restoration recovery", the upper extremity injury prevention and education needs of patients with tSCI or ntSCI, as well to describe sub-populations, their needs, recovery and responsiveness to intervention using this inclusive approach. The selected RG&M indicators will be integrated into the larger SCI-High Project framework to create a group of indicators and related best practices for routine implementation within a single rehabilitation program with project-wide report cards enabling cross-site comparisons of structure, process, and outcomes.

Conclusion

The plan is to implement this framework of RG&M indicators routinely in Ontario (across five tertiary rehabilitation sites- London, Hamilton, Toronto, Kingston, Ottawa), while looking at opportunities to expand its implementation to other provinces across Canada. The structure and process indicators will characterize the volume and type of therapy delivered to individuals with tetraplegia. The outcome indicators are intended to define the benefits of rehabilitation and were selected based on their perceived feasibility and robust psychometric properties established in individuals with SCI.[35,72]

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Conflicts of interest Dr. Kalsi-Ryan is the CEO of Neural Outcomes Consulting Inc., company that manufactures and distributes GRASSP. Naaz Kapadia is a PhD candidate funded by the Canadian Institute of Health Research (CIHR) Frederick Banting and Charles Best Canada Graduate Scholarship (CIHR-201810GSD-422024-294480); she also participated in the development of the commercial version of Myndmove, but she has no financial or personal conflicts. Dr. Wiest is funded by the Ontario Neurotrauma Foundation and the CIHR Health Systems Impact Fellowship (HI5-166374). Dr. Craven acknowledges support from the Toronto Rehab Foundation as the Toronto Rehabilitation Institute Chair in Spinal Cord Injury Rehabilitation, and receipt of consulting fees from the Rick Hansen Institute. Dr. S. Mohammad Alavinia, Farnoosh Farahani, Heather Flett, Dr. Dany H. Gagnon, Jennifer Holmes, Maryam Omidvar, and Prof. Molly Verrier report no conflicts of interest.

Declaration of interest None.

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