SCIRE
SPINAL CORD INJURY RESEARCH EVIDENCE
Professional

Spinal Cord Injury Rehabilitation Practices

Amber Harnett, MSc
Ali Bateman MD (PGY5)
Amanda McIntyre PhD (student) RN MSc
Ruchi Parikh MD
James Middleton PhD
Mohit Arora PhD
Dalton Wolfe PhD
Swati Mehta PhD

Our Partners:
PRAXIS Spinal Cord Institute
Ontario Neurotrauma Foundation / Fondation ontarienne de neurotraumatologie
UBC
LAWSON HEALTH RESEARCH INSTITUTE
Vancouver Coastal Health Research Institute
Western
St. Joseph's Health Care
icord

Key Points

Those with higher level and more severe injuries have longer rehabilitation LOS.

Rehabilitation LOS in the United States and Israel has become progressively shorter over the last few decades.

Most individuals make significant functional gains during inpatient rehabilitation.

A significant proportion of people improve one AIS (ASIA Impairment Scale) grade in the first few months post-injury, particularly those initially assessed AIS B and C.

Treatment times and intensities vary extensively between patients.

Increased therapeutic intensity has not been shown to have functional benefits.

Younger individuals with paraplegia appear to have shorter rehabilitation length of stays than older individuals.

Younger individuals may make greater functional gains during rehabilitation than older individuals.

Younger individuals with tetraplegia may make greater gains in neurological status during rehabilitation than older individuals and experience greater levels of independence.

Compared to younger individuals, those who are older are at an increased risk of developing pressure sores and being discharged to extended care.

In general, individuals with non-traumatic SCI may have reduced LOS and less functional improvement with rehabilitation as compared to those with traumatic SCI. Additional studies that better control for non-traumatic subtypes are required.

There are no significant effects of gender on rehabilitation outcomes.

Low socioeconomic status may affect access to comprehensive SCI care and in turn, rehabilitation outcomes.

Neither gender nor race effects have been demonstrated definitively for discharge destination, complications, rehabilitation LOS and neurological or functional status in patients with SCI.

More specialized, interdisciplinary acute SCI care is associated with faster transfers to rehabilitation and may result in fewer medical secondary complications, more efficient functional gains and reductions in overall mortality.

Earlier admission to specialized, interdisciplinary SCI care is associated with reduced length of total hospital stay and greater and faster rehabilitation gains with fewer medical secondary complications.

Prospective studies with stronger designs are needed to strengthen the evidence and provide more direction as to the optimal model of care.

Routine, comprehensive, specialist follow-up services may result in improved health in individuals with SCI.

Multidisciplinary outpatient rehabilitation programs may complement inpatient rehabilitation programs to promote functional recovery in individuals with SCI.

In the absence of protocolized SCI care, regular and accessible interdisciplinary follow-up and outpatient care can result in functional goal attainment.

Telerehabilitation may enhance patient satisfaction and improve functional outcomes in patients with SCI, although, some concerns exist regarding the cost and risks (i.e., medical liability) of implementation.

Individuals with SCI indicate there is a need for community reintegration programs.

Hospital readmission occurs frequently for persons with SCI (particularly the first year post injury), with UTIs, pressure ulcers, respiratory infections and musculoskeletal problems among the most frequent causes.

Persons with SCI have more physician contacts than the general population, particularly the first year post injury.

Persons with chronic SCI are more likely to seek out family physicians than specialists; however, a significant proportion are not satisfied with the services received as accessibility barriers, lack of routine screening and critical health concerns are often not addressed.

A lack of access to care for preventable conditions often leads to emergency department visits as a substitute for primary care, particularly in rural areas.

Table of Contents

Spinal Cord Injury Rehabilitation Practices

1.0 Executive Summary
2.0 Introduction

Spinal cord injury (SCI) rehabilitation practices of today were influenced greatly by the pioneering efforts of Sir Ludwig Guttman who was instrumental in the creation of specialized spinal units to care for injured soldiers returning to England during and after WWII (Guttmann, 1967). Eventual adoption of this more specialized and integrated approach followed in many additional jurisdictions (G. Bedbrook, 1979; Bors, 1967). They were bolstered by reports of reduced mortality and enhanced long-term survival which was attributed, in part, to more effective management of secondary conditions associated with SCI (e.g., urinary tract infections [UTI], pressure sores, respiratory conditions) (Geisler, Jousse, Wynne-Jones, & Breithaupt, 1983; Le & Price, 1982; Richardson & Meyer, 1981).

At present, the "ideal" scenario for modern SCI care is purported to be treatment in specialized, integrated centres with an interdisciplinary team of health care professionals providing care as early as possible following injury and throughout the rehabilitation process with appropriate discharge to the community characterized by ongoing outpatient care and follow-up (Donovan, Carter, Bedbrook, Young, & Griffiths, 1984; Tator, Duncan, Edmonds, Lapczak, & Andrews, 1995). This is best facilitated in one location within an organized "system" which is distinguished by seamless transitions as patients proceed from acute care through rehabilitation to outpatient care. While it is generally accepted that this "ideal," specialized, integrated approach should result in better outcomes, there is very little robust evidence that supports this directly. This is understandable, given the relatively low incidence of SCI, limitations in designing trials with adequate controls and the inherent difficulty in ascribing potential outcomes to such a multi-faceted process as rehabilitation. For these reasons, we have adopted an alternative approach within the present chapter with respect to the reviewed articles as compared to most other chapters in SCIRE. Many of the articles presented in the current chapter do not investigate a specific intervention, although they do describe rehabilitation outcomes and the various factors that are associated with producing optimal outcomes. Finally, for some included studies, the distinction between acute and rehabilitative care is somewhat blurred as they may have been conducted in centres or systems where these services integrated. The present chapter is focused on issues associated with rehabilitation care and we have attempted to clearly identify when acute care practice may have been merged within the reporting of rehabilitation research results.

3.0 What is SCI Rehabilitation

There is little consensus among rehabilitation specialists for what constitutes the essential elements of SCI rehabilitation. As with most forms of rehabilitation, rehabilitation programming for persons with SCI has been likened to a "black box" with research endeavors focused on the entire "rehabilitation package" rather than investigating the effectiveness of specific therapeutic practices (Gale Whiteneck, Cassaway, Dijkers, & Jha, 2009).

Although there is no internationally accepted definition of SCI rehabilitation and its essential elements, we have provided an operational definition that distinguishes between specialized SCI rehabilitation programs and general programs of rehabilitation. This definition was informed by a review of service offerings among the 16 SCI United States Model System rehabilitation programs and of Canadian SCI rehabilitation programs (SCISN Rehabilitation Escan; SCI Definitions

Framework). In addition, other resources were reviewed to establish this operational definition, including the WHO definition of rehabilitation (World Health Organization, 1981), the International Classification of Functioning, Disability and Health (World Health Organization, 2001) and efforts of clinicians and researchers to characterize the specialized treatment outcomes and methods involved in general rehabilitation (Stucki, Cieza, & Melvin, 2007) and SCI-specific rehabilitation (Bérard, Chougrani, & Tasseau, 2010; Blackwell, Krause, Winkler, & Stiens, 2001; M. DeVivo, 2007; Harvey, Lin, Glinsky, & De Wolf, 2009; Peter W New et al., 2013; Noonan et al., 2017; Rapidi et al., 2018) From this review, we have defined specialized SCI rehabilitation as follows:

> *A specialized SCI rehabilitation program provides comprehensive, individualized, and patient-focused rehabilitation services, for inpatient, transitional living, outpatient and follow-up care, to empower people with SCI and their families to achieve optimal quality of life continuing into the community (focusing on increasing self-reliance and gaining independence). Through organized regional referrals, care is delivered through a multidisciplinary team provided by board certified physician specialists and accredited allied health professionals (i.e., physical/ occupational/ speech/ recreational therapists, nurse specialists, psychologists, dieticians, engineers, social workers, etc.). As a rehabilitation program specialized in the care of people with SCI (experienced through trauma or disease), active participation in research is facilitated through university affiliated teaching institutions.*
>
> *Areas of further expertise may include specialized clinics (i.e., seating, audiology, pain, wound, sexuality/reproduction), respiratory and pediatric services, community/peer-support/fitness-wellness/health-maintenance/injury-prevention/day/combined (i.e., brain injuries, strokes, amputations, orthopedic conditions, neuromuscular diseases, burns and related disabilities) programs, support groups, vocational counseling, innovation/research updates, education, etc. Such specialized programs will be nationally (and possibly internationally) recognized and may be accredited through independent accreditation bodies (e.g., CARF/Commission on Accreditation of Rehabilitation Facilities; JCAHO/Joint Commission on Accreditation of Healthcare Organizations; AC/Accreditation Canada).*
>
> *Up to date, general rehabilitation programs would likely follow the ICF-based conceptualization of rehabilitation that "aims to enable people with health conditions experiencing or likely to experience disability to achieve and maintain optimal functioning in interaction with the environment" (Stucki et al., 2007). In contrast to a specialized SCI rehabilitation program, general rehabilitation programs are designed for individuals who have a medically stable disability, without additional active medical problems that could affect participation in therapies, with identifiable rehabilitation goals and a high potential to achieve those goals towards upgrading or maintenance of independence in the home and community. General medical oversight, nursing, and physical/occupational/speech therapies are commonly provided to facilitate a return to work or to functional independence for activities of daily living. A general program of rehabilitation may not be able to provide acute medical services and diagnostics, especially for complex medical conditions that involve multiple body systems such as SCI with or without impaired cognition. Special considerations could be made for these latter individuals but referral to an appropriate specialized rehabilitation program is the preferred option. Services are intended for residents of the regions immediately surrounding the rehabilitation facility and are not usually affiliated with a university-based teaching institution. Some general rehabilitation programs may have further areas of expertise such as wound treatment or pain management, etc.*

There have been to "unravel" the "black box" of rehabilitation as applied to persons with SCI (Gale Whiteneck et al., 2009). A practice-based evidence approach has been applied across multiple centres to identify and investigate the myriad practices that are conducted across the rehabilitation enterprise. The intention is to link this information with appropriate and systematic outcome measurement so as to evaluate the effectiveness of rehabilitation interventions (or combinations thereof). A critical step to facilitate this ambitious endeavor was to develop a taxonomy of rehabilitation interventions associated with every discipline contributing to SCI rehabilitation (Gassaway, Whiteneck, & Dijkers, 2009). The taxonomies provide a systematic means to enable clinicians to document the specific interactions and interventions they conduct with their patients and this has been completed for seven disciplines including physical therapy (PT) and occupational therapy (OT), psychology, speech language pathology (SLP), therapeutic recreation, social work and nursing (Natale et al., 2009; Ozelie et al., 2009; Wilson et al., 2009).

Efforts have also focused on characterizing the professional practice of physicians trained in the care of persons with SCI in the acute, subacute, and chronic phase of illness (Bérard et al., 2010; Peter W New et al., 2013; Noonan et al., 2017). Although there are differences in the methodology these authors used to characterize SCI rehabilitation, these authors outline common themes and recommendations for SCI rehabilitation, particularly in the inpatient setting. Collectively, these authors have identified that physicians with specialty training in the care of persons with SCI, such as specialists in physical and rehabilitation medicine (also known as physical medicine and rehabilitation or rehabilitation medicine in other jurisdictions), should serve as leaders and coordinators of care within a multidisciplinary setting, and that SCI rehabilitation units provide evidence-based care specific to medical and rehabilitation needs of persons with SCI (Bérard et al., 2010; Peter W New et al., 2013; Rapidi et al., 2018). This care should be individualized, patient-centreed, and responsive to patient and family/caregiver goals and satisfaction (Bérard et al., 2010; Rapidi et al., 2018). Rapidi et al. (2018) recommend that discharge from inpatient SCI rehabilitation be determined by the physical and rehabilitation medicine physician in coordination with the multidisciplinary team, patient and caregiver/family, taking into account the patients' individual circumstances, rehabilitation goal attainment, availability of outpatient resources, and nursing and medical needs. After inpatient rehabilitation, these authors recommend ongoing care by a physical and rehabilitation medicine specialist with multidisciplinary team member involvement when needed, which may be delivered by tele-health when appropriate, such as for patients in remote areas (Bérard et al., 2010; Rapidi et al., 2018). In addition, education and opportunities pertaining to healthy lifestyles, such as exercise programming, nutrition, and psychosocial interventions, as well as vocational rehabilitation to improve employment rates for patients with SCI who are of working age, are recommended as part of chronic SCI rehabilitation care (Rapidi et al., 2018).

4.0 SCI Rehabilitation Outcomes

Much research has been directed at describing outcomes following SCI rehabilitation and examining various factors that might be associated with favourable or unfavourable outcomes. Ethical and practical considerations limit the application of randomized controlled designs or other experimental designs in investigating methods for enhancing patient outcomes. Typically, investigators employ case series, case control or pre-post trial designs and often utilize correlational or predictive analyses (e.g., univariate or multivariate regression) of large single or multi-centre patient databases to determine specific associations or factors that are associated with optimal rehabilitation outcomes. Often these studies are quite large in scope as investigators explore relationships among a variety of socio-demographic and injury-related variables as they endeavour to determine optimal rehabilitation practice. Given the inherent breadth of findings present in individual studies, it is difficult to follow the same pattern of brevity and topic-focus found in other SCIRE chapters. In the present section we have taken a slightly different approach.

There are many types of outcomes that have been associated with SCI rehabilitation. In the present review, we will focus on the most commonly employed measures and have outlined these along with a few typical examples in Table 1. In particular, these include measures that examine the effectiveness of health delivery, as well as measures that assess functional, neurological and general health status of patients.

Table 1. Outcome Measure Types and Examples Relevant to SCI Rehabilitation

Outcome Measure Type	Specific Outcome Measures
Health Delivery Indicators	Length of Stay (LOS) Hospital Charges Discharge Destination
Functional Status	Functional Independence Measure (FIM) Barthel Index (BI)/ Modified Barthel Index (MBI) Spinal Cord Independence Measure (SCIM)
Neurological Status	American Spinal Cord Injury Association (ASIA) motor scores ASIA Impairment Scale (AIS) Frankel Index
Health Status	Incidence of secondary complications

It should also be noted that specific outcome measures can combine two of these outcomes such as in measures of efficiency. Most commonly, change scores for functional (e.g., FIM) or neurological (e.g., ASIA motor scores) measures are divided by LOS to get an average change for that particular measure, thereby providing an indication of the efficiency of the rehabilitation process in effecting change. Measures of this nature will be profiled in the sub-section for which the numerator is related. For example, ASIA motor score efficiency would be addressed under findings associated with neurological status.

4.1 Rehabilitation Length of Stay

Several authors have made comparisons of rehabilitation LOS between countries or across other jurisdictions (Burke, Burley, & Ungar, 1985) (Chan & Chan, 2005; Muslumanoglu et al., 1997; Pagliacci et al., 2003). Additionally, others have noted the trend for progressively shorter LOS over the past several decades, especially in the United States (De Vivo, Richards, Stover, & Go, 1991; M. DeVivo, 2007; Eastwood, Hagglund, Ragnarsson, Gordon, & Marino, 1999; SA., 1999) although there is also data from Israel that shows this as well (Ronen et al., 2004). Stover (1995) noted that reductions in the 1970s and early 1980s were likely due to increased efficiency of rehabilitation teams. More recent reductions in the United States have been attributed to restrictions imposed by payers (SA., 1999). Table 2 summarizes various reports in the literature for LOS organized by jurisdiction and also by the time period for which the data was collected. Data were only included in this table if the underlying sample was deemed representative of an overall heterogeneous population of individuals with SCI (i.e., unselected sample of a single or multi-centre study). Some data was included and grouped for evaluating specific issues and this has been appropriately indicated. In addition, data from studies for which it was not clear that the purpose of admission was for comprehensive inpatient rehabilitation (and may have involved acute care) were not included.

Table 2. Rehabilitation Length of Stay by Country and Sample Period

Study Jurisdiction Population N, Trauma &/or Nontrauma	**Sample Period**	**Length of Rehabilitation Stay (Days) (Mean unless otherwise stated)**
Franceschini et al., 2020 Switzerland (multi-centre) 497, Trauma	2013-2014	135 (Median)
Scivoletto et al., 2020 Italy (single centre) 414, Trauma & nontrauma	1996-2020	180.4±93[1] 154.5±84.8[2] [1]Complications versus [2]No Complications
Zhenrong et al., 2020 China (single centre) 2110, Trauma	2010-2019	113.5
Halvorsen et al., 2019 Norway (single centre) 349, Trauma	2012-2016	120
Burns et al. 2017 Canada (multi-centres) 16,579, Trauma	2004-2015 2007-2008 2012-2013 2010-2015 2007-2010 2010 2003-2014 2009-2010 2002-2007 2005-2008 2000-2009 2004-2008 2006-2010 2000-2007	89 138 60 36 17 25 28 227.6 207 55.8 169 55 41.3 73.6 (Median)
Ponfick et al. 2017 Germany (single centre) 113, Trauma & nontrauma	2013-2016	57.7
Whiteneck et al. 2012 USA (multi-centre) 1,376, Trauma	2007-2009	55.7
Zanca et al. 2013 USA (multi-centre) 1,357, Trauma	2007-NR	57

Study Jurisdiction Population N, Trauma &/or Nontrauma	**Sample Period**	**Length of Rehabilitation Stay (Days) (Mean unless otherwise stated)**
Whiteneck et al. 2011 USA (multi-centre) 600, Trauma	2007-2008	54.6
National SCI Statistical Centre 2009 USA (multi-centres) 26,852, Trauma	1973-1979 1980-1984 1985-1989 1990-1994 1995-1999 2000-2004 2005-2009	98 86 73 58 44 42 38 (Median)
DeVivo 2007 USA (multi-centres) 24,332, Trauma	1973-1981 1982-1986 1987-1991 1992-1996 1997-2001 2002-2006	108 89 80 59 50 45
Pollard & Apple 2003 USA (single-centre) 95, Trauma		47.3
Tooth et al. 2003 Australia (single centre) 167, Trauma	1993-1998	83.0 (Median)
Ronen et al. 2004 Israel (single centre) 1367, Trauma & Nontrauma	1962-1970 1971-1980 1981-1990 1991-2000 1996-2002	265±183[1] 107±85[2] 210±137[1] 124±90[2] 210±116[1] 115±222[2] 231±108[1] 91±81[2] 102±59[1] 106±51[2] [1]Trauma versus [2]Nontrauma
Scivoletto et al. 2005 Italy (single centre) 150, Trauma & Nontrauma	1997-2001	112.4±69.3
Scivoletto et al. 2003 Italy (single centre) 150, Trauma & Nontrauma	1997-2001	98.7±68.13
Pagliacci et al. 2003 Italy (multi-centre) 684, Trauma	1997-1999	135.5
Sumida et al. 2001 Japan (multi-centre) 123, Trauma	1994-1997	185.6±130.4 (N=60)[1] 267.8±171.6 (N=63)[2] [1]Early versus [2]delayed admission

Study Jurisdiction Population N, Trauma &/or Nontrauma	Sample Period	Length of Rehabilitation Stay (Days) (Mean unless otherwise stated)
Eastwood et al. 1999 USA (multi-centre) 3,904, Trauma	1990 1991 1992 1993 1994 1995 1996 1997	74.0±41.1 77.3±42.0 80.9±46.9 70.1±44.0 57.6±35.5 60.1±37.1 54.3±34.9 60.8±38.7
Morrison 1999 USA (single centre) 127, Trauma	1991 1995	95.8 (N=66) 54.2 (N=61)
Yarkony et al. 1990 USA (single centre) 1382, Trauma	1972-1986	68.1 (1986 data only)
Heinemann et al. 1989 USA (single centre) 338, unknown	1981-1985	84.9 (N=185)[1] 87.7 (N=153)[2] [1]Specialist versus [2]more general care
Yarkony et al. 1987 USA (single centre) 711, Trauma	1973-1980	84.9 (N=185)[1] 87.7 (N=153)[2] [1]Specialist versus [2]more general care

Rehabilitation LOS is also known to vary according to neurological status and data from studies reporting LOS organized by level of injury (i.e., paraplegia versus tetraplegia) or completeness are shown in Table 3. This is organized by jurisdiction (country) and the time period over which the sample was analyzed.

Table 3. Rehabilitation Length of Stay by Neurological Status

Study Jurisdiction Population N, Trauma &/or Nontrauma	Sample Period	Length of Stay Result (Mean – in days) (±SD if available)
Whiteneck et al. 2012 USA (multi-centre) 1,376, Trauma	2007-2009	• AIS ABC paraplegia – 44.8 (N=373) • AIS ABC high tetraplegia – 74.5 (N=294) • AIS ABC low tetraplegia – 66.5 (N=204) • AIS D tetraplegia – 32.7 (N=161)
Whiteneck et al. 2011 USA (multi-centre) 600, Trauma	2007-2008	• AIS ABC paraplegia – 44.9 (N=223) • AIS ABC high tetraplegia – 74.1 (N=132) • AIS ABC low tetraplegia – 64.9 (N=151) • AIS D tetraplegia – 33.6 (N=94)

Study Jurisdiction Population N, Trauma &/or Nontrauma	Sample Period	Length of Stay Result (Mean – in days) (±SD if available)
Chan & Chan 2005 China (Hong Kong) (single centre) 33, Trauma	2002	• AIS D paraplegia – 79.42±20.07 (N=3) • AIS ABC low paraplegia – 52.00±1.41 (N=2) • AIS ABC high paraplegia – 55.8±43.0 (N=2) • AIS D tetraplegia – 143.75±69.25 (N=4) • AIS ABC low tetraplegia – 215.9±56.1 (N=7) • AIS ABC high tetraplegia – 146.5±75.4 (N=6)
Ronen et al. 2004 Israel (single centre) 1367, Trauma & Nontrauma	1962-2002	• A 267±182[1] 231±128[2] • B 340±213[1] 153±108[2] • C 203±130[1] 112±77[2] • D 156±96[1] 73±183[2] [1]Trauma versus [2]Nontrauma
Tooth et al. 2003 Australia (single centre) 167, Trauma	1993-1998	• Incomplete paraplegia – 43.0 • Complete paraplegia – 96.5 • Incomplete tetraplegia – 64.5 • Complete tetraplegia – 206.0 (Median)
Morrison 1999 USA (single centre) 127, Trauma	1995 1991	• Paraplegia -46.7 Tetraplegia – 61.9 • Paraplegia -82.2 Tetraplegia – 110.9
DeVivo et al. 1990 USA (single centre) 661, Trauma	1973-1985	• Incomplete paraplegia – 46.3[1], 50.6[2] • Complete paraplegia – 62.2[1], 62.9[2] • Incomplete tetraplegia – 59.7[1], 71.3[2] • Complete tetraplegia – 90.4[1], 83.8[2] ([1]Early (N=284) versus [2]later (N=377) admitted patients)
Yarkony et al. 1990 USA (single centre) 1382, Trauma	1972-1986	• Paraplegia – 54.3 (1986 data only) • Tetraplegia – 82.8
Heinemann et al. 1989 USA (single centre) 338, unknown	1981-1985	• Paraplegia – 68.7[1], 70.7[2] • Tetraplegia – 98.0[1], 103.4[2] [1]Specialist (N=185) versus [2]more general (N=153) care.
Yarkony et al. 1987 USA (single centre) 711, Trauma	1973-1980	• Incomplete paraplegia – 78.2 • Complete paraplegia – 83.4 • Incomplete tetraplegia – 107.6 • Complete tetraplegia – 135.3
Woolsey et al. 1985 USA (single centre) 100, Trauma	Unknown (pre 1985)	• Paraplegia – ~105 • Tetraplegia – ~165

Discussion

As seen in Tables 2 and 3, rehabilitation LOS varies widely from country to country. While no investigators have systematically analyzed country-by-country variation it is apparent that the United States has typically shorter rehabilitation LOS compared to other countries reporting data. Most data originated in the United States, bolstered by the development of the United States model systems database, with reports from other countries for the most part limited to a handful of descriptions of single-centre experience.

Within the United States, the trend for progressively shorter rehabilitation LOS has continued to 2009. Across separate reports, authors (Center, 2009; Center., 2005; M. DeVivo, 2007; Eastwood et al., 1999; SA., 1999) have indicated reduced LOS from the period between 1973 to 2006. Eastwood et al. (Eastwood et al., 1999) examined the large United States Model systems database of individuals with traumatic SCI (N=3,904) and reported annual mean LOS values from 1990 to1997. For these years, the highest value was 80.9 days in 1992 and the lowest was 54.3 days in 1996. Mean LOS values for 1990-1992 seemed stable at higher values, with 1994-1997 values lower and 1993 at an intermediate value. DeVivo (M. DeVivo, 2007) has reported on the same dataset over a longer period beginning in 1973 (N=24,333), to extend the trend to a LOS of 45 days in 2006. Morrison (SA., 1999) performed a direct comparison of 1991 versus 1995 mean LOS values in the largest SCI rehabilitation in the United States in order to assess the effect of shorter rehabilitation LOS on functional outcomes. These authors confirmed an even more striking difference between these 2 years given an average LOS of 95.8 days in 1991 as compared to 54.2 days in 1995 ($p<0.001$). Other reports have described reductions over earlier periods, most notably multi-centre investigations associated with the United States Model Systems databases (De Vivo et al., 1991). These same trends are apparent by looking at the public data available from the United States National SCI Statistical Centre (Center, 2009; Center., 2005). The most recent reports with American data show that LOS continues to average approximately 54.6-57.0 days; data was reported on patients with traumatic SCI from multiple centers between 2007 and 2009 (G. Whiteneck et al., 2011; G. Whiteneck, Gassaway, Dijkers, Heinemann, & Kreider, 2012; Zanca, Dijkers, Hammond, & Horn, 2013). One recent German report by Ponfick (Ponfick, 2017) showed that rehabilitation LOS between 2013 and 2016 were comparable to American rates (mean=57.7 days).

It is uncertain if the same patterns have been seen in non-Model System centres or in other countries, although it is clear from a single-centre report from Israel analyzing LOS decade by decade that significantly lower LOS was seen beginning in 1996 as compared to earlier time periods (Ronen et al., 2004). Data from this report and also reports from other countries: [Australia (Burke et al., 1985; Tooth, McKenna, & Geraghty, 2003); Canada (Burns et al., 2017); China (Chan & Chan, 2005; Zhenrong, Fangyong, & Yao, 2020); Italy (Pagliacci et al., 2003; G. Scivoletto, Marcella, Floriana, Federica, & Marco, 2020); Japan (Sumida et al., 2001); Netherlands (Schonherr, Groothoff, Mulder, & Eisma, 1999); Norway (Halvorsen et al., 2019a); Switzerland (Marco Franceschini et al., 2020)] indicate LOS remains significantly longer than reported in United States data.

A low-cost, low intensity, outpatient rehabilitation program is reported by a Columbian group (Lugo, Salinas, & Garcia, 2007) (N=42) where in-patient rehabilitation was shortened to an average of 13.5 days and augmented with 18 month, interdisciplinary out-patient rehabilitation follow-up. This low-cost intervention achieved adequate functional goals, although these were achieved over a longer period due to the lack of accessibility to continuous and intensive therapy. This report might inform payer-directed LOS reduction efforts which may be driven by a focus on costs and may not necessarily circumvent any consequences associated with reductions to LOS by an increased attention to outpatient services.

Also apparent from Table 3 is the relationship of longer LOS associated with higher level of injury and greater severity of injury. Similar patterns were seen in all studies describing rehabilitation LOS for individuals with varying injuries. That is, the greatest mean rehabilitation

LOS values were seen for those with complete tetraplegia (especially high level) whereas the shortest mean values occurred for those with incomplete paraplegia (Chan & Chan, 2005; M. J. DeVivo, Kartus, Stover, & Fine, 1990; Tooth et al., 2003; G. Whiteneck et al., 2011; G. Whiteneck et al., 2012) although this relationship of level and injury severity was only a non-significant trend in the data from Israel (Ronen et al., 2004).

Conclusions

There is level 3 evidence (from predominately American studies; (M. J. DeVivo et al., 1990; A. W. Heinemann et al., 1989; SA., 1999; G. Whiteneck et al., 2011; G. Whiteneck et al., 2012; Woolsey, 1985; Yarkony et al., 1987; Yarkony et al., 1990)) that rehabilitation LOS has become progressively shorter between 1973 and 2009. For other countries, only investigators from Israel (Ronen et al., 2004) have published data in a single report that is consistent with this trend.

There is level 3 evidence (based on several studies; (Chan & Chan, 2005; M. J. DeVivo et al., 1990; Tooth et al., 2003; G. Whiteneck et al., 2011; G. Whiteneck et al., 2012)) that those with higher level and more severe injuries have longer rehabilitation LOS.

Those with higher level and more severe injuries have longer rehabilitation LOS.

Rehabilitation LOS in the United States and Israel has become progressively shorter over the last few decades.

4.2 Neurological and Functional Status

Several studies have identified patterns of neurological and/or functional improvement over the first few months post-injury. Most of these studies examine neurological and/or functional status and associated changes between rehabilitation admission and discharge. Table 4 summarizes various reports in the literature for neurological and/or functional status organized by jurisdiction and by the time period for which the data was collected. Data were only included if the underlying sample was deemed representative of an overall heterogeneous population of individuals with SCI (i.e., unselected sample of a single or multi-centre study).

Table 4. Neurological and/or Functional Status (by Country and Sample Period)

Study Jurisdiction N, Trauma &/or Nontrauma	Outcome Measure and Sample Period	Neurological and/or Functional Change with Rehabilitation
Halvorsen et al., 2019 Norway (multi-centre) 349,Trauma	AIS 2012-2016	• For those initially classified as AIS A, 77% remained grade A at discharge.

Study Jurisdiction N, Trauma &/or Nontrauma	Outcome Measure and Sample Period	Neurological and/or Functional Change with Rehabilitation
Scivoletto et al., 2020 Italy (single centre) 414, Trauma & nontrauma	SCIM 1996-2020	• Functional status at admission and discharge of the patients without complications was significantly better than the functional status of patients with complications (SCIM at admission: 21.8±16.5[2] versus 16.1±12.4[1]; SCIM at discharge: 57.9±23.2[2] versus 47.9±25[1]; p<.05) • [1]Complications versus [2]No Complications
Wilde et al., 2020 USA (single centre) 188, Trauma	AIS 2011-2017	• AIS score did not vary significantly between directly admitted or transferred patients at the time of rehabilitation discharge (p>.05)
Gedde et al., 2019 Norway (single centre) 174, Trauma & nontrauma	AIS 2004-2013	• AIS score did not significantly differ between those with traumatic versus non-traumatic injuries.
Gupta et al. 2009 India (single centre) 64, Nontrauma	AIS BI 2005-2008	• AIS score showed significant neurological recovery during rehabilitation (p=0.001). • # of patients at AIS A went from 31.3% to 18.8%, AIS B from 20.3% to 7.8% and AIS C/D from 48.4%to 73.4% between admission and discharge. • BI scores showed significant functional recovery (p=0.000).
Moslavac et al. 2008 Croatia (single centre) 154, Trauma	AIS 1991-2001	• 49% were AIS A at admission -of these, 93% remained an A at discharge, 5% to C and 1% to D. • 8% were AIS B at admission -of these, 38%remained B at discharge, while 31% of these improved to a C, 23% to a D and 8% to E. • 21% were AIS C at admission – of these, 3% deteriorated to A, 9% remained C, 67% improved to D and 21% to E. • 12% were AIS D at admission – of these, 26% remained D and 74% improved to E. • 8% were AIS E at admission – all of these remained E.
DeVivo 2007 United States multi-centre N=24,333 Trauma	AIS FIM 1973-2006	• For 2002-2006, among injuries that were initially neurologically complete, 15.1% became incomplete by discharge. Among ASIA B injuries, 45.2% improved at least one grade, whereas 54.3% of ASIA C injuries improved to at least ASIA D injuries. This suggests some gains in the likelihood of neurologic improvement over the past 30 years. • Mean gain in FIM motor score decreased by 3.38 points during the past 20 years (p<0.01) although FIM efficiency increased (p<0.01) (discrepancy due to reduced LOS). • FIM motor scores at admission & discharge decreased significantly during the past 20 years (p<0.0001).

Study Jurisdiction N, Trauma &/or Nontrauma	Outcome Measure and Sample Period	Neurological and/or Functional Change with Rehabilitation
Müslümanoğlu et al. 1997 Turkey $N_{Initial}$=52 N_{Final}=10	AIS FIM	1. Neurological assessments (Motor scores and light touch scores) showed increases from admission to discharge for those with incomplete injuries (p<0.001) but not complete injuries. 2. FIM showed increases from admission to discharge for those with incomplete injuries (p<0.05) and those with complete paraplegia (p<0.05) but not complete tetraplegia. • FIM scores (p<0.05), but not motor scores or light touch scores showed significant increases from discharge to 1 year post-discharge in a subsample of 10 with paraplegia.
Chan & Chan 2005 China (single centre) 33, Trauma	FIM 2002	• All groups showed ↑ in FIM motor scores from admission to discharge but these were only significant for tetraplegia AIS D. • All patient groups (i.e., levels and severity of injury) had similar FIM motor scores at discharge as noted by American Consortium for Spinal Cord Medicine (1999).
Pollard & Apple 2003 USA (single centre) 95, Trauma	AIS	• Most gains in motor and sensory scores were found in first year. An average of 35 motor points (18% during acute care, 53% during rehabilitation, 8% during the remainder of the year) and 46 sensory points (46% during acute care, 46% during rehabilitation, 8% during the remainder of the year) were recovered. • People with Brown Sequard and Central Cord injuries had more improvement in motor scores but not sensory scores than those with anterior cord (p=0.019).
Pagliacci et al. 2003 Italy (multi-centre) 684, Trauma	AIS 1997-1999	• ↑ was associated with AIS B and C, shorter LOS, earlier admission and no complications (especially pressure sores).
Tooth et al. 2003 Australia (single centre) 167, Trauma	FIM 1993-1998	• ↑ from 68.7 (admission) to 102.2 (discharge) due almost entirely to gains in motor FIM scores. • Total FIM scores were lowest for those with complete tetraplegia and highest for those with incomplete paraplegia. Those with complete tetraplegia had the least change in FIM scores.
Catz et al. 2002 Israel (single centre) 250, Trauma	Frankel 1962-1992	• ↑ in 27% of those admitted at A, B or C to D or E. None initially admitted as A were able to achieve D or E. 43% of those initially C ↑ to D and 11% to E. 47% of those initially D ↑ to E.
Celani et al. 2001 Italy (multi-centre) 859, Trauma & Nontrauma	Frankel 1989-1994	• ↑ of at least 1 grade was seen in ~1/3 of those with traumatic SCI. Initial B and C had greatest probability of ↑. 76% of those initially at C and 67% of those initially at B ↑. With non-traumatic SCI, 64% of those initially at C and 44% of those initially at B ↑.

Study Jurisdiction N, Trauma &/or Nontrauma	Outcome Measure and Sample Period	Neurological and/or Functional Change with Rehabilitation
Sumida et al. 2001 Japan (multi-centre) 123, Trauma & Nontrauma	FIM 1994-1997	• Compared earlier versus later admission to rehabilitation and showed ↑ FIM and FIM efficiency for the earlier group • Greater proportion of persons ↑ by at least 1 AIS grade with earlier admission. • Increasingly greater likelihood of ↑ by 1 AIS grade for initial AIS of B, C or D than A.
Marino et al. 1999 USA (multi centre) 3585, Trauma	AIS 1988-1997	• Increasingly greater likelihood of ↑ to D for initial AIS of C>>B>>A.
Müslüman-oğlu et al. 1997 Turkey (single centre) 52, Trauma & Nontrauma	AIS FIM1992-1995	• ↑ in ASIA motor scores and light touch scores for those with incomplete injuries but not complete injuries. • FIM showed ↑ f for those with incomplete injuries and those with complete paraplegia but not complete tetraplegia.
DeVivo et al. 1991 USA (multi-centre) 13,763, Trauma	AIS FIM1973-1990	• Proportion showing ↑ were 10.3% (A), 45.2% (B), 55.9% (C), 7.3% (D) versus no change 89% (A), 50.3% (B), 41.5% (C), 90.5% (D) versus declined 4.5% (B), 2.6% (C), 2.0% (D) • From 1973-1990 the proportion of incomplete patients increased from 40% to 55.2%. • Average FIM gain was 37 (incomplete paraplegia, 36 (complete paraplegia), 34 (incomplete tetraplegia and 15 (complete tetraplegia).
Yarkony et al. 1987 USA (single centre) 711, Trauma	MBI 1973-1980	• ↑ in total scores & self-care and mobility subscores. • greater ↑ for incomplete versus complete and for those with paraplegia versus tetraplegia.
Burke et al. 1985 Australia (single centre) 262, Trauma	Frankel	• 31% of people improved, 66% remained unchanged, and 3% deteriorated. 23% initially complete became incomplete and 40% of those initially incomplete improved.

Discussion

The AIS represents an internationally recognized system for the classification of individuals with SCI, and as such, has been employed to characterize overall improvement in the neurological status of people with SCI (ASIA 2002). It is somewhat similar to earlier systems such as the Frankel grading classification system. The AIS is an ordinal 5 grade scale classifying individuals from “A” to “E” with “A” designating those with complete SCI and “E” designating individuals with normal sensory and motor function. Most notably, DeVivo (M. DeVivo, 2007), Pagliacci et al. (Pagliacci et al., 2003), Celani et al. (Celani, Spizzichino, Ricci, Zampolini, & Franceschini, 2001), Marino et al. (Marino, Ditunno, Donovan, & Maynard, 1999) and DeVivo et al. (De Vivo et al., 1991) employed large multi-centre databases and found that individuals with incomplete injuries (especially AIS B or C) were more likely to improve at least 1 grade over the course of rehabilitation. In particular, DeVivo et al. (De Vivo et al., 1991) reported that 45.2% and 55.9% of those initially admitted as AIS B and C respectively improved at least 1 AIS grade as compared to only 10.3% and 7.3% of individuals initially classified as AIS A or D respectively. Over the period of 1973-2006, DeVivo (M. DeVivo, 2007) reported that there was an 8.8% increase in likelihood that those classified as AIS A at admission would improve to AIS B at discharge. Other reports have presented similar findings and data culled from a sample of these investigations have been summarized in Figure 1. Figure 1 illustrates the proportion of persons assessed at each AIS (or Frankel) grade status (i.e., A, B, C or D) at discharge from rehabilitation relative to the proportion of people at each AIS level at rehabilitation admission for each of the studies (Burke et al., 1985; Catz et al., 2002; M. DeVivo, 2007; Marino et al., 1999; Pagliacci et al., 2003; Sumida et al., 2001). This provides an indication of the degree of neurological recovery that occurs over the period of rehabilitation. It should be noted that for each study (i.e., jurisdiction) the admission and discharge time points are variable relative to the time of injury although these all are typically within the first six months following injury. In addition, all datasets consisted of relatively unselected patients with traumatic SCI, other than the report by Sumida et al. (Sumida et al., 2001) which included patients with SCI of both traumatic and non-traumatic etiology.

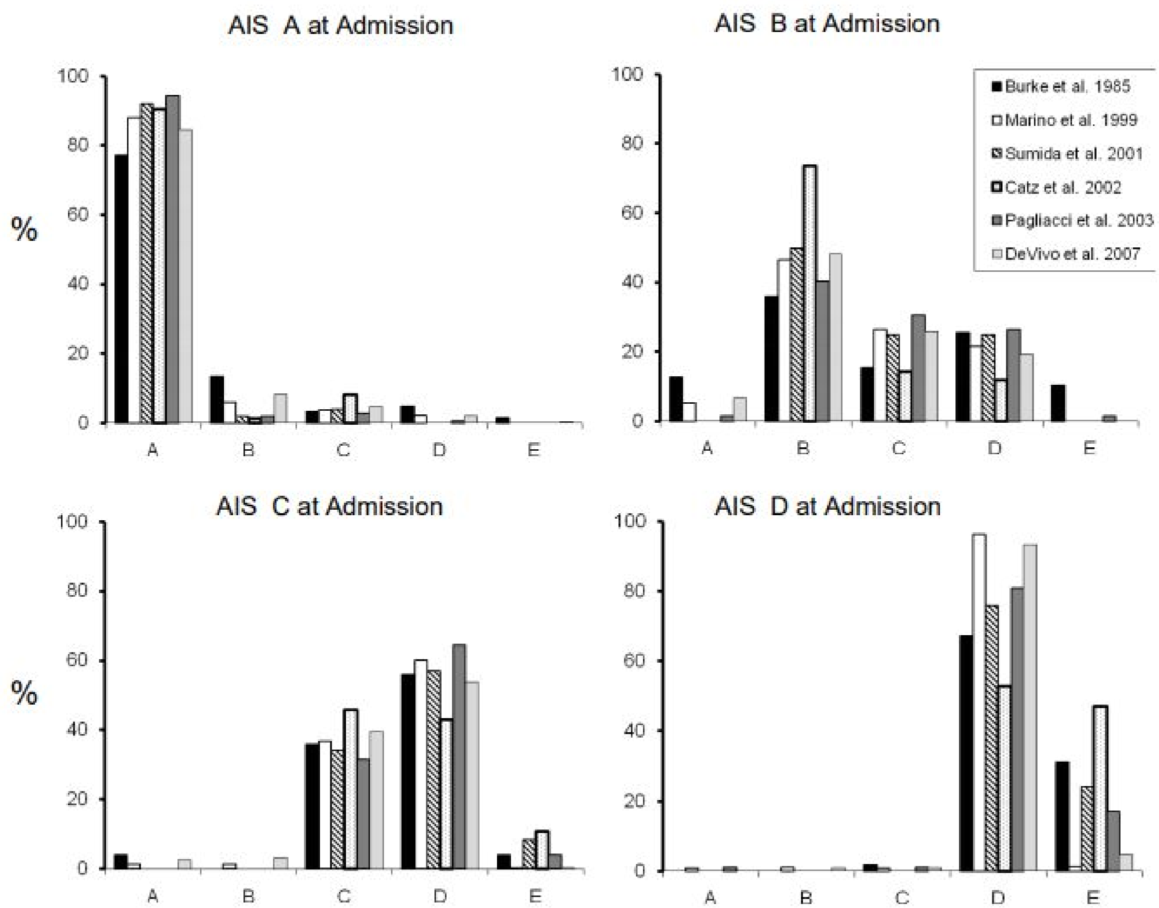

Figure 1. Discharge or Frankel Grades for each initial admission AIS grade

As one can see, it is striking how similar these patterns of AIS conversion rates are across health systems (i.e., Australia, Israel, Italy, Japan, United States) with only Catz et al. (Catz et al., 2002) (i.e., Israel) providing somewhat disparate results. Overall, AIS A patients comprise from 40-50% of individuals admitted to SCI rehabilitation centres and a similar, but slightly reduced percentage of those are assessed AIS A at discharge. AIS B and AIS C patients comprise ~5-15% and ~10-30% respectively with moderate reductions in these percentages manifest at discharge. Conversely, those assessed AIS D comprise ~15-25% of those admitted which increases to ~25-35% by discharge.

The majority of patients assessed AIS A at admission remain so at discharge, whereas a much greater proportion of individuals assessed AIS B recovered significant motor function during rehabilitation so as to be assessed AIS C or D. The conversion rate is even greater for those assessed initially as AIS C but much less so for those assessed as AIS D.

These conversion rates appear similar across these studies and therefore provide a base for comparison with other findings. For example, Moslavac et al. (Moslavac, Dzidic, & Kejla, 2008) reported data for a centre-based study in Croatia at which all national cases of SCI resulting from road traffic accidents received rehabilitative care. In this case, although 49% of people were AIS A at admission and 93% of these remained AIS A at discharge, there was a tendency for greater proportions of persons making conversions to AIS D or E of those assessed with an incomplete injury at admission. Importantly, Wilde et al. (2020) found that interhospital transfer does not reduce functional recovery.

Similarly, many individuals also make significant functional gains during comprehensive inpatient rehabilitation. Most often, functional status has been assessed at admission and discharge from rehabilitation using the FIM (Chan & Chan, 2005; De Vivo et al., 1991; Muslumanoglu et al., 1997; Tooth et al., 2003) or MBI (Yarkony et al., 1987). Typically, functional gains are greater with rehabilitation for those with incomplete injuries as compared to complete injuries and for those with paraplegia as compared to those with tetraplegia (Chan & Chan, 2005; De Vivo et al., 1991; Muslumanoglu et al., 1997; Tooth et al., 2003). In particular, DeVivo et al. (1991) reported similar average FIM gains for those with incomplete and complete paraplegia and incomplete tetraplegia (i.e., 37, 36 and 34 respectively) but much reduced gains for those with complete tetraplegia (i.e., 15). While, Scivoletto et al. (2020) found that complications (mostly pressure ulcers) negatively effect patients' functional status. For the most part increases seen in the FIM have been attributed to motor FIM changes with little change in cognitive FIM scores at least partly due to an apparent ceiling effect (Chan & Chan, 2005).

Conclusions

There is level 4 evidence that a significant proportion of people (~50%) initially assessed as AIS B and C will improve by at least one AIS grade in the first few months post-injury concomitant with inpatient rehabilitation. Fewer individuals (~10%) initially assessed as AIS A and D will improve by one AIS grade.

There is level 4 evidence that individuals make significant functional gains during inpatient rehabilitation, more so for those with complete and incomplete paraplegia and incomplete tetraplegia.

Most individuals make significant functional gains during inpatient rehabilitation.

A significant proportion of people improve one AIS (ASIA Impairment Scale) grade in the first few months post-injury, particularly those initially assessed AIS B and C.

5.0 Factors affecting Rehabilitation Outcomes

5.1 Intensity

Although it is commonly assumed that the therapies delivered during inpatient rehabilitation are effective, there is little direct evidence that demonstrates a clear relationship between rehabilitation practices and enhanced functional recovery (Allen W Heinemann, Hamilton, Linacre, Wright, & Granger, 1995). Due to the nature of SCI, outcomes are influenced by a complicated mix of demographic, clinical and environmental factors, rather than intensity or frequency of treatment (Al-Habib et al., 2011; Allen W Heinemann, Linacre, Wright, Hamilton, & Granger, 1994; M. Johnston & Miller, 1986; Truchon et al., 2017). To complicate things further, there is no evidence that establishes a recommended intensity or amount of therapy that should be delivered to produce a desired result. Indeed, a paucity of studies have examined this issue.

Table 5. Effect of Intensity on Rehabilitation Outcomes

Author, Year Country Research Design PEDro Score Total Sample Size	**Methods**	**Outcome**
Kapadia et al. (2014) Canada Post-Hoc Analysis $N_{Initial}$=27, N_{Final}=27	**Population***: Conventional Occupational Therapy 1 (COT1; n=5):* Mean age=60.8yr; Gender: males=5, females=0; Level of injury: C3=3, C4=2; Severity of injury: not reported; Time since injury=43.6 days. *COT2 (n=12):* Mean age=44.75yr; Gender: male=9, female=3; Level of injury: C4=7, C5=5, C6=1; Severity of Injury: AIS level B=4, C=8. Time since injury=58.33 days. *Functional Electrical Stimulation (FES) + COT (FES+COT; n=10)*: Mean age=43.2yr; Gender: male=8, female=2; Level of injury: C3=1, C4=3, C5=1, C6=5; Severity of Injury: AIS level B=4, C=5, D=1; Time since injury=69.9 days. **Intervention:** Retrospective post hoc analysis of data from phase I and II RCTs. COT1 received 45hr of therapy, COT2 received 80hr, and FES + COT received 40hr of each therapy for a total of 80hr. Outcome measures were assessed at baseline and at discharge. **Outcome Measures:** FIM, self-care sub-scores of the Spinal Cord Independence Measure (SCIM).	1. Mean scores on the FIM self-care sub-score were 12.8, 10, and 20.1 for the COT1, COT2, and FES+COT groups, respectively. 2. The mean scores on the SCIM self-care sub-scores for the COT1, COT2, and FES-COT groups were 2.6, 3.16, and 10.2 for the COT1, COT2, and FES-COT groups, respectively. 3. All groups showed improvement in FIM and SCIM scales from baseline to discharge; however, no significant differences were observed between groups ($p>0.05$).
Whiteneck et al. (2011) USA Observational $N_{Initial}$=600, N_{Final}=600	**Population***: Total Group (TG; n=600):* Mean age=37.2±16.6yr; Gender: males=80.5%, females=19.5%; Level of injury: C1-C4=132, C5-C8=151, T1 and below=317; Severity of injury: AIS level A, B, C=506, D=94; Time since injury=31.7±28.1 days. *Group 1(C1-C4, AIS A, B, C; n=132):* Mean age=41.9±17.0yr; Gender: males=80.3%, females=19.7%; Time since injury=42.1±30.5 days. *Group 2(C5-C8, AIS A, B, C; n=151):*	1. The average length of stay for the TG was 55±37 days, during which 180±106hr of total treatment was received, or 24±5hr per wk. 2. Across individual groups, treatment times and intensities varied extensively and were not correlated with patient, injury or clinician characteristics (R_2=0-0.19).

Author, Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
	Mean age=33.7±15.6yr; Gender: males=80.8%, females=19.2%; Time since injury=33±28.7 days. *Group 3(T1 and below, AIS A, B, C; n=223):* Mean age=33.4±14.2yr; Gender: males=81.6%, females=18.4%; Time since injury=31.5±28.1. *Group 4(T1 and below, AIS D; n=94):* Mean age=45.3±18.5yr; Gender: males=77.7%, females=27.3%; Time since injury=15.5±12.4 days. **Intervention:** No intervention. Prospective observation of time patients spent in various therapeutic activities. Patients were group by neurological level and completeness of injury. Outcome measures were assessed for the duration of the patient's stay and correlated with patient, injury and clinician characteristics. **Outcome Measures:** Total time spent in rehabilitation, total minutes of treatment per week, LOS	3. LOS was weakly correlated with total hours of therapy (R_2=0.47).
Whiteneck et al. (2012) USA Observational $N_{Initial}$=1376, N_{Final}=1032	**Population***: Total Group (TG; n=1032):* Mean age=37.7±16.7yr; Gender: males=81%, females=19%; Level of injury: C1-C4=294, C5-C8=204, T1 and below=534; Severity of injury: AIS level A, B, C=874, D=161; Time since injury=31.0±27.8 days. *Group 1(C1-C4, AIS A, B, C; n=294):* Mean age=40.9±17.1yr; Gender: males=82%, females=18%; Time since injury=38.9±32.2 days. *Group 2(C5-C8, AIS A, B, C; n=204):* Mean age=33.8±15.8yr; Gender: males=81%, females=19%; Time since injury=33±28.2 days. *Group 3(T1 and below, AIS A, B, C; n=373):* Mean age=32.7±13.3yr; Gender: males=80%, females=20%; Time since injury=30.0±26.0. *Group 4(T1 and below, AIS D; n=161):* Mean age=48.1±18.1yr; Gender: males=84%, females=16%; Time since injury=16.5±13.0 days **Intervention:** No intervention. Prospective observation of time patients spent in various therapeutic activities, correlated with patient characteristics and outcome. Patients were group by neurological level and completeness of injury. Outcome measures were assessed at rehabilitation discharge and 1yr post injury. **Outcome Measures:** Total time spent in rehabilitation, LOS, FIM, CHART physical independence, social integration, mobility	1. Patient characteristics (level of injury, admission FIM, time from trauma to rehabilitation, age at injury, BMI≥30) are strong predictors of motor FIM outcome at discharge (p<0.05). 2. More time in PT was associated positively with motor FIM score at discharge and 1yr follow-up (p<0.001), as well as CHART physical independence (p<0.001), social integration (p=0.015), mobility dimensions (p<0.001), smaller likelihood of rehospitalization after discharge (p<0.001) and reporting of pressure ulcers (p=0.001) at 1yr follow-up. 3. More time in therapeutic recreation had similar positive associations with social integration (p=0.006), mobility (p=0.009), smaller likelihood of rehospitalization (p=0.010) and reporting of pressure ulcers (p=0.023) at discharge and follow-up. 4. Time spent in other disciplines had fewer and mixed relationships. OT was negatively associated with discharge FIM score (p=0.003) and positively associated with pressure sore at

Author, Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
	dimensions, rehospitalization, pressure ulcer incidence.	follow-up (p=0.026). No significant associations between social work and discharge/follow-up FIM. Psychology was negatively associated with CHART physical independence (p=0.002). Nursing positively associated with rehospitalization (p=0.037). SLP negatively associated with pressure sore incidence at follow-up (p=0.017).
Heinemann et al. (1995) USA Case Series $N_{Initial}$=264, N_{Final}=246	**Population:** *SCI:* Mean age=38.9yr; Gender: males=79%, females=21%. **Intervention:** No intervention. Retrospective review of variation in therapy intensity (OT, BT, SLP, psychology). Also examined effect of various other factors including length of stay, interruptions, onset days, admission scores and age. **Outcome Measures:** FIM (motor, cognitive, total), FIM Efficiency (motor or cognitive) all collected at Discharge.	1. When analyzed together, none of the individual therapy intensities were predictive of improved outcomes. When analyzed individually, very little was significant in the prediction with only greater LOS associated with greater achievement of potential motor gains (p<0.05) and interrupted rehab associated with less achievement of potential motor gains (p<0.05). 2. Patients with >intervals between onset and admission had less motor function at discharge, achieved less of their potential motor gains and made less efficient motor gains (all p<0.05). 3. Therapy intensity was predicted to a small degree by the various functional, demographic and medical variables (psychology intensity had highest explained variance with 26.3%; SLT 17.2%, All therapies combined 16.6%, OT 7.3%, PT 6.5%). 4. People with lower cognitive and motor function at admission receive more intense therapy (all therapy types p<0.05).

Discussion

Heinemann et al. (1995) employed a case series design to examine the effect of increased therapeutic intensity on functional rehabilitation outcomes as indicated by motor, cognitive and total FIM scores as well as FIM efficiencies. These investigators performed a comprehensive chart review of patients with SCI (N=106) and traumatic brain injury (N=140) to determine the number of 15-minute therapy units delivered in the provision of PT, OT, SLP, and psychology services. They then performed multiple regression analyses to determine if the amount of therapy was associated with positive outcomes. For the most part, there was little evidence that increased therapeutic intensity had any effect on improving outcomes for the SCI sub-sample although the paucity of well-controlled studies in this area limits the strength of the conclusions that can be drawn.

Similarly, in a post-hoc analysis of data obtained from several phase I and II randomized controlled trials, Kapadia and colleagues (2014) compared the therapeutic benefits of single versus double dose conventional OT to functional electrical stimulation plus conventional OT. Although improvements were seen in all groups on the FIM and SCIM self-care sub-scores, no significant differences were observed between groups. This suggests that the intensity of rehabilitation alone may not improve hand function in individuals with incomplete sub-acute C3-C7 SCI.

Through a series of observational studies, Whiteneck et al. (2011; 2012) examined the nature, extent and intensity of treatments patients received during inpatient rehabilitation to determine if patient characteristics or treatment quantity affect rehabilitation outcomes at rehabilitation discharge and one-year post injury. In the first study, they found that treatment times and intensities varied extensively across patient groups. However, these differences were not explained by patient, injury or clinician characteristics, instead, a weak association was found between length of stay and total hours of therapy received. In the second study, they determined which treatment interventions and intensities are associated with positive outcomes. Interestingly, more time in PT and therapeutic recreation was positively associated with improved motor outcomes, physical independence, social integration, reduced rehospitalization and incidence of pressure ulcers. Although these results are promising, more research is necessary to examine this relationship and draw any definitive conclusions.

In this regard, physical and rehabilitation medicine guidelines established by Rapidi and colleagues (2018) suggest that physicians act as coordinators of their multidisciplinary team to "establish objectives of treatment decisions/plans/programs according to the specific needs of individuals with SCI in terms of duration and intensity of a specific treatment, in agreement with team and patient/family caregivers."

Conclusions

There is level 4 (from one case series; (Allen W Heinemann et al., 1995) that increased therapeutic intensity may not be associated with functional benefit as measured by the Functional Independence Measure.

There is level conflicting level 5 evidence (from one observational study and one post-hoc analysis; (Kapadia et al., 2014; G. Whiteneck et al., 2012) that increased therapeutic intensity may be associated with increased functional benefit (as measured by the FIM and SCIM), independence, social integration, reduced hospitalizations and pressure ulcer incidence.

There is level 5 evidence (from one observational study; (G. Whiteneck et al., 2011) that treatment times and intensities vary extensively between patients and may be associated with length of stay, rather than patient, injury, or clinician characteristics.

Treatment times and intensities vary extensively between patients.

Increased therapeutic intensity has not been shown to have functional benefits.

5.2 Age

In the coming decades, demographic changes will result in a significant increase in the proportion of older individuals all over the globe. For example, in Canada it is estimated that seniors will account for 30% of the population by 2068, an increase of 17% from 2018 (Statistics Canada, 2019). When considering epidemiological evidence that found the highest rates of SCI-related hospital admission following trauma in Ontario, Canada was for those over 70 years of age, this has significant implications for the delivery of rehabilitation and support services to this group of patients (Pickett, Campos-Benitez, Keller, & Duggal, 2006). In addition, many centres in various places around the world provide rehabilitation services to individuals with spinal cord damage as the result of a variety of non-traumatic etiologies and often these people are much older than those injured due to trauma (W. O. McKinley, Seel, Gadi, & Tewksbury, 2001; W. O. McKinley, Tewksbury, & Mujteba, 2002; Peter W New, 2005; G Scivoletto, Morganti, Ditunno, Ditunno, & Molinari, 2003). Given these trends, it is important to understand the effects of age on rehabilitation outcomes. Several studies have investigated age as an interventional trait to identify which individuals may have better rehabilitation outcomes.

Table 6. Effect of Age on Rehabilitation Outcomes

Author Year **Country** **Research Design** **PEDro Score** **Total Sample Size**	**Methods**	**Outcome**
Franceschini et al., 2020 Switzerland Observational $N_{initial}$=510, N_{final}=497	**Population:** Mean age=50±20yr; Gender: male=402, female=95, Level of injury: not reported; Severity of injury: AIS A=173, B=78, C=122, D=104, E=2. **Intervention:** No intervention. Prospective analysis of patient characteristics on functional gains and discharge destination in patients with SCI admitted to rehabilitation. **Outcome measures:** SCIM	1. Older individuals were less likely to improve on the SCIM(p<.05).
Furlan & Fehlings, (2009) Canada Observational $N_{Initial}$=499, N_{Final}=396	**Population***: Younger Individuals (<65yr; n=455):* Mean age=31.9yr; Gender: males=82.9%, females=17.1%; Level of injury: cervical=65.6%, thoracolumbar=24.4%; Severity of injury: complete=51.9%, incomplete=48.1%; Time since injury=not reported. *Older Individuals (>65yr; n=44):* Mean age=75yr; Gender: male=92.7%, female=7.3%; Level of injury: cervical=89.5%, thoracolumbar=10.5%; Severity of Injury: complete=29.5%, incomplete=70.5%; Time since injury=not reported.	1. Mortality rates among older individuals were significantly greater than younger individuals (38.6% versus 3.1%; p<0.0001). 2. Among survivors, age was not significantly correlated with motor recovery or change in pain scores in the acute and chronic stages of SCI (p>0.05). 3. Older individuals experienced greater functional deficit (as measured by FIM) than younger individuals (p<0.05) despite experiencing similar rates of sensorimotor recovery.

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
	Intervention: No intervention. Prospective observational analysis of the impact of age on mortality, impairment and disability among adults with acute traumatic SCI. Outcome measures were assessed at 6wk, 6mo and 12mo. **Outcome Measures:** Mortality, FIM.	
Osterthun et al. (2009) Netherlands Case control $N_{Initial}$=919, N_{Final}=919	**Population:** *Traumatic SCI:* Mean age=43.4yr; Gender: male:female=2.8:1; Level of injury: tetraplegia=49.6%; Severity of injury: complete=52.3%; *Non-traumatic SCI:* Mean age=57.2yr; Gender: male:female=1.2:1; Level of injury: tetraplegia=24.2%; Severity of injury: complete=25.9% **Intervention:** No intervention. Those with traumatic SCI were compared to those with non-traumatic SCI. **Outcome Measures:** Functional status, LOS.	1. Age and better functional status on admission was associated with shorter length of stay (p=0.001). 2. Functional outcome was not correlated with age; however it was significantly correlated with functional status at admission and LOS.
Gupta et al. (2008) India Case Control $N_{Initial}$=76, N_{Final}=76	**Population:** *Traumatic (n=38):* Mean age=32.86yr; Gender: males=34, females=4. *Non-traumatic (n=38):* Mean age=31.10; Gender: males=16, females=22 **Intervention:** Admission/discharge data from all surviving non-traumatic and traumatic spinal cord lesion (SCL) patients in a neurological rehabilitation facility was assessed over a 2yr period. **Outcome Measures:** Length of stay; AIS collected at admission and discharge.	1. The traumatic SCL group was not significantly different in age, marriage, education or socioeconomic factors (p>0.05).
McKinley et al. (2008) USA Case control $N_{Initial}$=594, N_{Final}=594	**Population:** Infection related spinal cord disease (*IR-SCD):* Mean age=53.3yr; Gender: males=64.7%; Level of injury: paraplegia=74%. Traumatic SCI: Mean age=40.4yr; Gender: males=83.8%; Level of injury: paraplegia=49% **Intervention:** No intervention. Data was reviewed of individuals diagnosed with infection related SCD against those with traumatic SCI. **Outcome Measures:** Acute and rehabilitation hospital LOS, FIM motor scores, FIM motor change, FIM motor efficiency, AIS change.	1. When compared with traumatic SCI (n=560), patients with IR-SCD comprised significantly less of the SCI/D rehabilitation admissions (3% versus 61%), were older (53 versus 40yr), and more often female (35% versus 16%). Injuries were more commonly located in the thoracic region (48% versus 38%).
Tchvaloon et al. (2008) Israel Case series $N_{Initial}$=143, N_{Final}=143	**Population:** Mean age=37.8yr; Gender: M:F=4.95:1; Level of injury: C=43%, T=49.3%, L=7.7%; Severity of injury: complete=41%, incomplete=59%.	1. Negative association was seen between survival and age at injury (p<0.001) and pressure sores (p=0.006). 2. No significant effect on recovery was seen due to age at injury,

Author Year **Country** **Research Design** **PEDro Score** **Total Sample Size**	**Methods**	**Outcome**
	Intervention: No intervention. Data from patients with a SCI due to a road accident was analyzed. **Outcome Measures:** Neurological recovery, Functional recovery, complications.	gender, presence of pressure sores and complications.
Anzai et al. (2006) Canada Case series $N_{Initial}$=52, N_{Final}=52	**Population:** Mean age=45.3yr; Gender: males=77%, females=23%; Level of injury: C4=63%; Severity of Injury: AIS A=60% **Intervention:** No intervention. Retrospective chart review was conducted on patients admitted to GF Strong Spinal Cord Program between 1994 and 2003. **Outcome Measures:** Discharge destination, factors associated with discharge to ECU.	1. Older individuals had a 4% increased risk of being discharged to an extended care unit. 2. Good levels of social support were found to be protective factors 3. Pre-existing medical conditions were associated with 10 times greater risk 4. Unemployment and not having funding from insurance were associated with 5 times greater risk.
New et al. (2005) Australia Case Series $N_{Initial}$=70, N_{Final}=62	**Population:** *Non-traumatic SCI:* Mean age=69yr; Level and severity of injury: AIS B-D, tetraplegia=32.9%, AIS A, paraplegia=8.6%, AIS B-D=58.6%; Time since injury: <7 days=78.6%; Time to rehabilitation=30.9 days. **Intervention:** No intervention. Outcomes associated with non-traumatic SCI rehabilitation were assessed. **Outcome Measures:** Demographics, clinical characteristics, LOS, Discharge setting, level of lesion and AIS, FIM, mobility, bowel and bladder function. Collected at admission to and discharge from rehabilitation.	1. Those subjects' male, younger, more mobile, more independent bowel and bladder function and less severe AIS grades were more likely to be discharged home.
Ronen et al. (2004) Israel Observational $N_{Initial}$=1367, N_{Final}=1367	**Population***: Traumatic Spinal Cord Injury (TSCI; n=250):* Mean age=34.5±15.3yr; Gender: males=5, females=0; Level of injury: cervical=37%. Thoracic=32%, lumbosacral=31%; Severity of injury: Frankel grade A=74, B=42, C=100, D=34; Time since injury=59 days. *Non-Traumatic Spinal Cord Injury (NTSCI; n=1117):* Mean age=47.1±16.8yr; Gender: male=9, female=3; Level of injury: cervical=32%, thoracic=44%, lumbosacral=24%; Severity of Injury: Frankel grade A=32, B=146, C=506, D=433. Time since injury=51mo. **Intervention:** No intervention. Retrospective analysis of the factors that influence hospital LOS. **Outcome Measures:** LOS, SCI etiology, SCI severity, decade of admission to	1. The mean LOS was 239±168 for individuals with TSCI and 106±137 for individuals with NTSCI. 2. SCI severity, etiology and decade of admission to rehabilitation were significantly associated with LOS ($p<0.001$). 3. SCIM II gains were positively associated with LOS, when LOS was short (<70 days; r=0.81-0.82, $p<0.001$). 4. Age had no significant effect on LOS ($p=0.08$).

Author Year Country Research Design PEDro Score Total Sample Size	**Methods**	**Outcome**
	rehabilitation, and Spinal Cord Independence Measure II (SCIM II).	
Pollard & Apple (2003) USA Case Series $N_{Initial}$=412, N_{Final}=95	**Population:** Mean age=not reported; Gender: not reported; Level and severity of injury: incomplete tetraplegia; Time since injury=not reported. **Intervention:** No intervention. Retrospective review of patients with incomplete tetraplegia to determine what patient characteristics, injury variables and management strategies are associated with improved neurological outcomes. **Outcome Measures:** Motor score, motor level sensory score, sensory level and ASIA grade.	1. Neurological recovery was not significantly related to gender, race, type of fracture, or mechanism of injury (p>0.05). 2. Improved motor outcomes were observed in patients <18yr (34±18) when compared to those >18yr (24±19) (p=0.002). However, no significant difference was observed in sensory scores between groups (p>0.05).
Kennedy et al. (2003) UK Case Control (Inadequate control) $N_{Initial}$=200, N_{Final}=192	**Population:** Traumatic and non-traumatic SCI: Mean age=40.7yr; Gender: males=147, females=45; Level and severity of injury: incomplete tetraplegia=23%, complete tetraplegia=21%, complete paraplegia=34%, incomplete paraplegia=22; Mean time post-injury to admission=28.8 days. **Intervention:** No intervention. Various outcomes associated with inpatient rehabilitation focusing on goal attainment in younger versus older patients. **Outcome Measures:** Needs Assessment Checklist (NAC) collected within 2wk of mobilization and within 6wk of discharge.	1. Improvements were noted in ↓ "percentage to be achieved" scores for all nine areas of need (p<0.0001). No significant differences were seen between age groups. 2. Those with complete lesions showed greater improvement in bowel management than those with incomplete lesions (p<0.005) and those with tetraplegia showed greater improvement in the area of skin care than those with paraplegia group (p<0.005) Otherwise no other differences. 3. Mobility needs of older subjects were significantly higher compared to the younger subjects (p<0.005) initially, but lower for the community score (p=0.01). Higher scores (i.e., more unmet need) assessed close to discharge were noted for older versus younger for the areas of skin management (p<0.01), bladder management (p<0.01), bowel management (p<0.05) and mobility (p<0.01).
Scivoletto et al. (2003) Italy Case Control $N_{Initial}$=284, N_{Final}=284	**Population:** Mean age=50.4yr; Gender: males=184, females=100; Level of injury: cervical=81, thoracic=148, lumbosacral=55; Severity of injury: AIS: A-D; Mean time post-lesion to admission=56.9 days. **Intervention:** No intervention. Various outcomes associated with inpatient rehabilitation focusing on younger (<50)	1. Although LOS was longer for younger patients (111.3±63.88 versus 89±69.9, p<0.008) which was related to a higher incidence of incomplete lesions and etiology, a matched-block sub-analysis (n=130) showed differences were not significant. 2. Neurological recovery was more frequent with younger group

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
	versus older (>50) patients. Mean LOS was 98.7±68.1 days. **Outcome Measures:** LOS, AIS, ASIA Motor Index, BI, Rivermead Mobility Index (RMI), Walking Index for SCI (WISCI), Discharge Destination. All collected at admission and discharge.	(p=0.006) and for those at AIS C. Matched group sub-analysis showed more ASIA grade (p=0.027) and motor score improvements in younger group. 3. Gains for independence of daily living measures (BI and RMI) were significantly greater for younger group (p<0.001). 4. Younger age group had more people reach independent walking levels on WISCI than in older group (p<0.004). Similar findings for related subscales in BI and RMI. 5. Younger age group had more people reach autonomous bladder (p=0.005) and bowel control (p=0.014) than in older group. Similar findings for bladder subscales in BI.
McKinley et al. (2002) USA Case Control $N_{Initial}$=381, N_{Final}=183	**Population:** Non-traumatic SCI secondary to stenosis (n=81) versus traumatic SCI (n=102) within a single centre; Matching from N=381 sample on paraplegia versus tetraplegia and completeness. **Intervention:** No intervention. Various outcomes associated with non-traumatic (stenosis) versus traumatic SCI rehabilitation were compared. Outcome measures were collected at admission to and discharge from rehabilitation. **Outcome Measures:** LOS, charges, Discharge rates to home, FIM (score, change and efficiency).	1. As compared to those with trauma (before matching), those with stenosis were significantly (p<0.01): • Older (64.1 versus 44.4). • More likely female (38.8 versus 21.2%) • More likely to have paraplegia (69.4% versus 45.5%) • More likely to be incomplete injury (AIS C or D) (100% versus 49.3%)
Seel et al. (2001) USA Case Control $N_{Initial}$=180, N_{Final}=180	**Population:** Traumatic SCI from United States Model Systems database: Gender: male, female, three equal (N=60) age groups (18-39, 40-59, >59) matched for neurological level and ASIA classification, paraplegia, AIS A-D, 84% admitted within 21 days post-injury. **Intervention:** No intervention. Various outcomes associated with inpatient acute and rehabilitation care focusing on age effects by comparing results between three age categories. **Outcome Measures:** LOS, Charges, ASIA motor index score, FIM, change scores and efficiencies for FIM. All collected at admission to acute care and admission to rehabilitation care and discharge.	1. FIM improvement was greater for the younger and middle group that for the older group (p<0.001). FIM efficiency was greater for the young group as compared to the 2 older groups (p<0.001). 2. There were no significant differences in ASIA motor index scores at any of the time points across the different ages. 3. No systematic significant differences were noted between the 3 age groups for acute care LOS or hospital charges. 4. Rehabilitation LOS was significantly shorter for younger than middle or older groups. There was no difference in

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
		associated hospital charges for the 3 groups. 5. All age groups were equally likely to be discharged to a private residence (≥92%).
Van der Putten et al. (2001) Netherlands Case Series $N_{Initial}$=100, N_{Final}=100	**Population:** *Non-traumatic SCI:* mean age=55yr; Gender: male=54%; Level of injury: cervical=49%, upper thoracic=21%, lower thoracic and lumbar=22%; Time from onset to rehabilitation=4.8yr. **Intervention:** No intervention. Optimal outcomes were regressed against various factors associated with non-traumatic rehabilitation. **Outcome Measures:** Demographics, clinical characteristics, level of lesion and AIS, FIM motor score and change score. Collected at admission to and discharge from rehabilitation.	1. Age (i.e., younger), etiology (i.e., hereditary pathology) and lesion level (i.e., cervical) were individually associated with improved functional outcomes but did not improve prediction of overall model.
Eastwood et al. (1999) USA Case Series $N_{Initial}$=5180, N_{Final}=3904	**Population***:* Age: <21=882, 21-30=1182, 31-40=803, 41-50=484, >50=552, unknown=1; Gender: males=3157, females=747; Level and severity of injury: paraplegia-incomplete=777, paraplegia-complete=1202, tetraplegia-incomplete=1065, tetraplegia-complete=782, unknown=78; Time since injury=not reported. **Intervention:** No intervention. Retrospective chart review of patients discharged between 1990 and 1997 with traumatic SCI to determine predictors of acute rehabilitation length of stay and their association with medical and social outcomes. Outcomes were assessed at rehabilitation discharge and one yr following injury. **Outcome Measures:** Rehabilitation LOS, age, race, method of bladder management, tetraplegia, education, marital status, discharge disposition, one-year presence of pressure ulcers, rehospitalization, place of residence, days per week out of residence.	1. From 1990 to 1997 rehabilitation LOS declined from 74 days to 60 days, while discharge to nursing homes and rehospitalizations increased. 2. Lower FIM score at admission, year of discharge, method of bladder management, tetraplegia, race, education, marital status, discharge disposition, and age were related to longer LOS ($p<0.05$) 3. At one yr following injury lower FIM, injury level, and age were related to the presence of pressure ulcers, rehospitalization, residence, and time spent out of residence ($p<0.05$). 4. Of those discharged to nursing homes, 44% returned home by year one and these individuals had higher functional status and were younger.
Cifu et al. (1999) USA Case Control $N_{Initial}$=375, N_{Final}=375	**Population:** Traumatic SCI from United States Model Systems database: Gender: male and female, three equal (N=125) age groups (18-34, 35-64, >64) matched for neurological level and completeness, tetraplegia, AIS A-D, 85% admitted within 21 days post-injury. **Intervention:** No intervention. Various outcomes associated with inpatient acute	1. The younger the age group, the greater the FIM motor score improvement and greater FIM motor efficiency. 2. The younger and middle age groups had significantly greater ASIA motor index score increases and efficiency than the older age group.

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
	and rehabilitation care focusing on age effects by comparing results between three age categories. **Outcome Measures:** LOS, Charges, ASIA motor index score, FIM, change scores and efficiencies for FIM and ASIA motor index, Discharge destination. All collected at admission to acute care and admission to rehabilitation care and discharge.	3. No systematic significant differences related to age were noted for acute care or rehabilitation Length of Stay or hospital charges. 4. The older the age group, the more likely individuals would be discharged to an institutional setting.
Cifu et al. (1999) USA Case Control (Inadequate control) $N_{Initial}$=2,169, N_{Final}=2,169	**Population:** Traumatic SCI from United States Model Systems database: Mean age =31.72yr; Gender: males =83%, females =17%; Level of injury: paraplegia; Severity of injury: AIS: A-D. **Intervention:** No intervention. Various outcomes associated with inpatient acute and rehabilitation care focusing on age effects by comparing results between 11 age categories. Mean acute LOS was 13.2±16.92 days. Mean rehabilitation LOS was 56.76±34.28 days. **Outcome Measures:** LOS, Charges, ASIA motor index score, FIM, change scores and efficiencies for FIM and ASIA motor index. All collected at admission to acute care and admission to rehabilitation care and discharge.	1. FIM improvement was less for people ≥60 than those younger. 2. There were no significant differences in ASIA motor index scores, change scores or efficiency scores across different ages. 3. No systematic significant differences were noted for acute care LOS or hospital charges. 4. Rehabilitation LOS was longer and associated hospital charges greater for older individuals (trend beginning for those >54 and peaking in the 60-64 age group). 5. Younger age groups were more likely injured as a result of vehicular crashes or violence while older groups were more likely injured as a result of falls or other events including being struck by falling objects, pedestrian accidents and medical/surgical complications.
McKinley et al. (1999) USA Case Control $N_{Initial}$=4035, N_{Final}=58	**Population:** Non-traumatic SCI secondary to neoplastic cord compression admitted over 5 years (within a single centre (n=29) versus traumatic SCI (n=29) from the United States Model Systems database matched by age, level of injury and AIS; Age =57.8 years; AIS A-D; C4-L2. **Intervention:** No intervention. Various outcomes associated with rehabilitation care of non-traumatic (neoplastic cord compression) versus traumatic SCI. Outcome measures were collected at admission to and discharge from rehabilitation. **Outcome Measures:** LOS, Discharge destination, FIM (total score, change and efficiency).	1. As compared to those with trauma (before matching), those with neoplastic cord compression were: • Older (57.8 versus 30.45). • More likely to have paraplegia (88.2% versus 52.5%) • More likely to be incomplete (88.2% versus 56.7%) • No different FIM efficiency
Devivo et al. (1990) USA	**Population:** *Group 1 (Age=1-15yr):* Gender: males=80%, females=20%; Level	1. Increase in age at admission was significantly related to increase in:

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
Case control $N_{Initial}$=866, N_{Final}=866	of injury: paraplegia=47.5%, tetraplegia 52.5%; Severity of injury: complete=52.5%, incomplete=47.5%; Time since injury=not reported. *Group 2 (Age=16-30yr):* Gender: males=84.6%, females=15.4%; Level of injury: paraplegia=52.1%, tetraplegia=47.9%; Severity of injury: complete=55%, incomplete=45%; Time since injury=not reported. *Group 3 (Age=31-45yr):* Gender: males=81.1%, females=18.9%; Level of injury: paraplegia=52%, tetraplegia =48%; Severity of injury: complete=45.9%, incomplete=54.1%; Time since injury=not reported. *Group 4 (Age=46-60yr):* Gender: males=79%, females=21%; Level of injury: paraplegia=46%, tetraplegia=54%; Severity of injury: complete=43%%, incomplete=57%; Time since injury=not reported. *Group 5 (Age=61-86yr):* Gender: males=70%, females=30%; Level of injury: paraplegia=28.6%, tetraplegia 71.4%; Severity of injury: complete=36.2%, incomplete=63.8%; Time since injury=not reported. **Intervention:** No intervention. Patients were retrospectively divided into five age groups: *Group 1 (1-15yr), Group 2 (16-30yr), Group 3 (31-45yr), Group 4 (46-60yr), Group 5 (61-86yr).* Data was then used to assess the effects of age on rehabilitation outcome. **Outcome Measures:** Relationship of age with clinical outcomes.	• Cervical injuries with patients over 60 yr old (p=0.006). • Diabetes (p<0.001). • Obesity (p=0.007). • Alcohol abuse (p<0.001). • Heart disease (p<0.001). • Arthritis (p<0.001). • Pulmonary embolus (p<0.001). • Gastrointestinal hemorrhage (p=0.008). • Pneumonia (p=0.003). • Mechanical ventilatory support use (p=0.004). 2. Increase in age was significantly related to a decrease in: • Percentage of complete lesions (p=0.039). 3. No significant relationship was found between age at admission and: • Number of days from injury to admission. • Initial length of hospitalization of acute care. • Hospital charges. • Days of rehospitalization in the second year post injury. 4. Increasing age at admission was inversely related to percentage of patients independent in self-care activities at discharge (p=0.016).
Yarkony et al. (1988) USA Case control $N_{Initial}$=708, N_{Final}=708	**Population:** *Traumatic SCI:* Mean age=28.3yr; Gender: males=82%, females=18%; Level and severity of injury: complete paraplegia=30%, incomplete paraplegia=15%, complete tetraplegia=27%, incomplete tetraplegia=28%. **Intervention:** No intervention. Patients were retrospectively divided into four groups: *Group 1 (6-19yr), Group 2 (20-39yr), Group 3 (40-59yr), Group 4 (60-88yr)* and data was analyzed. **Outcome Measures:** Relationship of age to clinical outcomes.	1. Age was not significantly related to admission or discharge MBI. 2. Admission and discharge MBI was related to level of injury (p<0.001) and severity (p<0.001). 3. Increase in age in patients with complete paraplegia was related to increased dependence in seven functional skills including: bathing, upper and lower body dressing, stair climbing, and transfers to chair, toilet and bath.

Discussion

Similar approaches involving case control study designs have been employed by various investigators to examine the effect of age on rehabilitation outcomes. However, in the present review, studies employing some form of matching across different age groups were assessed as representing a higher level of evidence (Cifu, Huang, et al., 1999; M. J. DeVivo et al., 1990; G Scivoletto et al., 2003; Seel et al., 2001; Yarkony et al., 1988) as compared to those deemed as having an inadequate method of controlling for potential confounds (Cifu, Seel, et al., 1999; Kennedy et al., 2003). Several of these studies have demonstrated differences between age groups for a variety of rehabilitation outcomes although there were also some contradictory findings within these studies, albeit some of this may have been due to variation between the sampling frames and methods employed in each study.

For example, Seel et al. (2001) and Cifu et al. (1999) reported reduced rehabilitation LOS for those with paraplegia due to trauma or mixed etiology Osterthun et al. (2009) whereas no differences were seen in investigations of those with tetraplegia due to trauma (Cifu, Huang, et al., 1999) and also with the mixed sample of people with both traumatic and non-traumatic SCI (Ronen et al., 2004; G Scivoletto et al., 2003).

Yarkony et al. (1988) was the first to look at the independent effect of age on rehabilitation outcomes in SCI. This study found that functional outcome was only related to age in patients with complete paraplegia. Among these individuals, Yarkony et al. (1988) demonstrated a trend between increase in age and increased dependence in seven functional skills including: bathing, upper and lower body dressing, stair climbing, and transfers to chair, toilet and bath. Yarkony attributed this trend to the fact that there is a “greater residual muscle function” in these individuals. Devivo et al. (1990) later supported this trend by demonstrating an inverse relationship between patients’ age and their level of independence in self-care activities. Anzai et al. (2006) and Eastwood et al. (1999) reported that older individuals were at increased risk of being discharged to an extended care facility due to pre-existing co-morbidities and lack of social and financial supports. Similarly, New et al. (2005) reported that younger individuals were more likely to be discharged home

Conversely, all studies examining functional change showed that younger individuals demonstrated greater functional improvements as indicated by increases on the FIM (i.e., motor FIM scores, change scores, efficiencies) (Cifu, Huang, et al., 1999; Cifu, Seel, et al., 1999; Furlan & Fehlings, 2009; Pollard & Apple, 2003; Seel et al., 2001; van der Putten et al., 2001), BI (G Scivoletto et al., 2003) or SCIM (Marco Franceschini et al., 2020). These similar results were obtained from studies involving those with paraplegia (Cifu, Seel, et al., 1999; Seel et al., 2001), tetraplegia (Cifu, Huang, et al., 1999) and a mixed sample comprised of those with both traumatic and non-traumatic SCI (G Scivoletto et al., 2003). On the other hand, Kennedy et al. (2003) employed the Needs Assessment Checklist developed internally at Stoke-Mandeville, United Kingdom and demonstrated that there were few systematic age-related differences associated with goal attainment in a mixed traumatic, non-traumatic sample. The Needs Assessment Checklist is a client-focused outcome measure that assesses the degree to which specific behavioural outcomes particularly relevant to the client are achieved. Tchvaloon et al (2008) (N=143) also reported no significant effect on recovery due to age at injury on an Israeli population of people with traumatic SCI.

In addition to functional outcomes, effective rehabilitation has also been associated with increases in neurological status as indicated by AIS or ASIA motor scores. Of the studies reviewed and utilizing measures of neurological status, both studies limited to those with paraplegia showed no age effects (Cifu, Seel, et al., 1999; Seel et al., 2001). Conversely, similar studies of those with tetraplegia or a mixed traumatic and non-traumatic SCI sample demonstrated that younger individuals were more likely to make significant neurological gains during inpatient rehabilitation (Cifu, Huang, et al., 1999; G Scivoletto et al., 2003). Additionally, conflicting findings exist in relation to mechanism of injury with Gupta and colleagues (2008) reporting that traumatic versus non-traumatic injuries are not associated with age. Conversely, McKinley et al. (2008; 1999; 2002) found that non-traumatic injuries are significantly associated with older age.

Despite mixed research regarding the impact of age on SCI rehabilitation, it is reasonable to assume that older individuals require individualized care. In light of this, guidelines established by Rapidi and colleagues (2018) suggest that therapeutic exercise programs in SCI should be prescribed and adapted to each individuals' needs, according to the neurological level of injury, age and comorbidities.

Conclusions

There is level 3 evidence (from four case control studies; (Cifu, Huang, et al., 1999; Cifu, Seel, et al., 1999; Osterthun et al., 2009; Seel et al., 2001) that shorter rehabilitation LOS is associated with younger versus older individuals with paraplegia. The same may not be true for those with tetraplegia or for mixed cohorts involving traumatic and non-traumatic SCI.

There is level 3 evidence (from four case control studies; (M. J. DeVivo et al., 1990; Kennedy et al., 2003; G Scivoletto et al., 2003; Yarkony et al., 1988) and one observational study (Marco Franceschini et al., 2020)) that age is inversely related to patient's independence level.

There is level 3 evidence (from five case control studies; (Cifu, Huang, et al., 1999; Cifu, Seel, et al., 1999; Kennedy et al., 2003; G Scivoletto et al., 2003; Seel et al., 2001) that younger as compared to older individuals are more likely to obtain greater functional benefits during rehabilitation.

There is level 3 evidence (from two case control studies; (Kennedy et al., 2003; G Scivoletto et al., 2003) that significant increases in neurological status during rehabilitation are more likely with younger than older individuals with tetraplegia or for mixed cohorts involving traumatic and non-traumatic SCI. The same may not be true for those with paraplegia.

There is conflicting level 3 evidence (from three case control studies; (Gupta et al., 2008; W. O. McKinley, Huang, et al., 1999; W. O. McKinley et al., 2002) that older individuals are more likely to experience a non-traumatic than traumatic SCI.

There is level 4 evidence (from one case series; (Tchvaloon et al., 2008) that older individuals are more at risk of developing pressure sores.

There is level 4 evidence (from two case series; (Anzai et al., 2006; Peter W New, 2005) that older individuals are more likely to be discharged to an extended care unit.

There is level 4 evidence (from one case series; (Eastwood et al., 1999) that age may be associated with longer length of rehabilitation stay.

There is level 4 and 5 evidence (from two case series and one observational study; (Furlan & Fehlings, 2009; Pollard & Apple, 2003; van der Putten et al., 2001) that younger patients are more likely to experience improved motor outcomes when compared to older individuals. However, both groups experience similar sensory deficits.

There is level 5 evidence (from one observational study; (Ronen et al., 2004) that age has no effect on length of acute hospital stay.

Younger individuals with paraplegia appear to have shorter rehabilitation length of stays than older individuals.

Younger individuals may make greater functional gains during rehabilitation than older individuals.

Younger individuals with tetraplegia may make greater gains in neurological status during rehabilitation than older individuals and experience greater levels of independence.

Compared to younger individuals, those who are older are at an increased risk of developing pressure sores and being discharged to extended care.

5.3 Traumatic versus Non-Traumatic SCI

Individuals sustaining damage to the spinal cord due to non-traumatic causes are often treated in specialized inpatient SCI rehabilitation centres more commonly associated with those with SCI due to traumatic etiologies. Various reports have estimated that one-quarter to one half of all cases seen in specialized SCI rehabilitation centres are associated with non-traumatic etiologies (W. O. McKinley, Seel, & Hardman, 1999; Muslumanoglu et al., 1997; van der Putten et al., 2001). Despite these significant numbers, relatively little systematic research is directed at non-traumatic SCI (W. O. McKinley et al., 2002; van der Putten et al., 2001). Common causes of non-traumatic SCI includes space occupying lesions such as tumours or prolapsed intervertebral discs, spondylosis such as that seen with degenerative spinal changes resulting in compression of the spinal cord, vascular ischemia as in arteriovenous malformations or spinal infarction, inflammation (e.g., idiopathic transverse myelitis, tropical spastic paraparesis, sarcoid) and those associated with congenital or familial etiologies (Adams & Salam-Adams, 1991; W. O. McKinley et al., 2001; W. O. McKinley, Seel, et al., 1999). Although estimates of the incidence of non-traumatic SCI have been provided (e.g., 8 per 100,000) (Kurtzke, 1975; W. O. McKinley et al., 2001), it is difficult to ensure accuracy given the heterogeneous nature of non-traumatic SCI and the variety of facilities and programs where these patients may receive care.

Studies comparing those with damage to the spinal cord due to non-traumatic versus traumatic etiologies have demonstrated a variety of systematic differences between these 2 patient groups. In general, those with non-traumatic SCI are more likely to be older, female, have paraplegia and have an incomplete injury than those with traumatic SCI (W. O. McKinley, Conti-Wyneken, Vokac, & Cifu, 1996; W. O. McKinley et al., 2001; W. O. McKinley et al., 2002; Peter W New, 2005).

Table 7. Differences in Traumatic versus Non-Traumatic SCI on Rehabilitation Outcomes

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
Non-traumatic versus Traumatic		
Osterthun et al. (2009) Netherlands Case control $N_{Initial}$=919, N_{Final}=919	**Population:** *Traumatic SCI:* Mean age=43.4yr; Gender: male:female=2.8:1; Level of injury: tetraplegia=49.6%; Severity of injury: complete=52.3%; *Non-traumatic SCI:* Mean age=57.2yr; Gender: male:female=1.2:1; Level of injury: tetraplegia=24.2%; Severity of injury: complete=25.9% **Intervention:** No intervention. Those with traumatic SCI were compared to those with non-traumatic SCI. **Outcome Measures:** Functional status, LOS.	3. Functional status at admission and gain during rehabilitation was significantly higher in patients with non-traumatic SCI (p<0.001). 4. No significant difference between the two groups was seen in their admission to rehabilitation. 5. Age and better functional status on admission was associated with shorter length of stay (p=0.001). 6. Functional outcome was not correlated with age; however it was significantly correlated with functional status at admission and LOS.
Bradbury et al. (2008) Canada Case control $N_{Initial}$=20, N_{Final}=20	**Population:** *SCI/TBI:* Mean age=35.9yr; Gender: males=7, females=3; Level of injury: C=6, L=1, T=3; Severity of injury: complete=3, incomplete=7; *SCI:* Mean age=36.3yr; Gender: males=7, females=3; Level of injury: C=6, L=1, T=3; Severity of injury: complete=3, incomplete=7. **Intervention:** No intervention. Rehabilitation data of patients with SCI and TBI was analyzed against those with SCI alone. **Outcome Measures:** Behavioral incidents, Personality Assessment Inventory, Stroop, FIM, costs.	1. No significant difference between the two was seen in motor FIM scores. 2. Patients with both SCI and TBI tended to stay longer in rehabilitation however this trend did not reach significance. 3. The difference in average cost of a dual diagnosis compared to the single SCI diagnosis had clinical significance ($169,638 versus $130,773, p=0.17). 4. Clinical significance was also reached in the total cost per FIM change score between the two groups (p=0.13).
Gupta et al. (2008) India Case Control $N_{Initial}$=76, N_{Final}=76	**Population:** *Traumatic (n=38):* Mean age=32.86yr; Gender: males=34, females=4. *Non-traumatic (n=38):* Mean age=31.10; Gender: males=16, females=22 **Intervention:** Admission/discharge data from all surviving non-traumatic and traumatic spinal cord lesion (SCL) patients in a neurological rehabilitation facility was assessed over a 2yr period. **Outcome Measures:** LOS, BI, AIS collected at admission and discharge.	2. The traumatic SCL group had significantly more males than females (p<0.05) and was not significantly different in age, marriage, education or socioeconomic factors. 3. LOS was 66.0±47.7 days (trauma) and 60.7±45.7 which was not significantly different between groups. 4. Both trauma and non trauma patients showed significant gains in function with BI increasing significantly from admission to discharge (p<0.05) although there was no between group differences. 2. AIS scores showed non traumatic patients had significantly more impairment than the traumatic at both admission and discharge (p=0.020, p=0.017) (Overall change in AIS not reported).
McKinley et al. (2008) USA Case control $N_{Initial}$=594, N_{Final}=594	**Population:** Infection related spinal cord disease (*IR-SCD):* Mean age=53.3yr; Gender: males=64.7%; Level of injury: paraplegia=74%.	3. When compared with traumatic SCI (n=560), patients with IR-SCD comprised significantly less of the SCI/D rehabilitation admissions (3% versus 61%), were older (53 versus

	Traumatic SCI: Mean age=40.4yr; Gender: males=83.8%; Level of injury: paraplegia=49% **Intervention:** No intervention. Data was reviewed of individuals diagnosed with infection related SCD against those with traumatic SCI. **Outcome Measures:** Acute and rehabilitation hospital LOS, FIM motor scores, FIM motor change, FIM motor efficiency, AIS change.	40yr), and more often female (35% versus 16%). Injuries were more commonly located in the thoracic region (48% versus 38%). 4. Patients with IR-SCD more often had incomplete injuries (94% versus 57%). 5. Thirty-two percent of IR-SCD patients had improvements in ASIA impairment scale classification. LOS was longer on acute care (25 versus 16 days), but similar on rehabilitation (36 versus 34 days), and with lower FIM motor changes (16.2 versus 22.8) during rehabilitation. 6. Patients with IR-SCD were less often discharged to home (56% versus 75%).
Ones et al. (2007) Turkey Case control $N_{Initial}$=194, N_{Final}=194	**Population:** *SCI Non-traumatic (n=63):* Mean age=49.87yr; Gender: males=30, females=33; Level of injury: paraplegia=52, tetraplegia=11; Severity of injury: complete=18, incomplete=45; Work status: working=22, not working=41. *Traumatic (n=131):* Mean age=35.82yr; Gender: males=91, females=40; Level of injury: paraplegia=98, tetraplegia=33; Severity of injury: complete=83, incomplete=48; Work status: working=98, not working=33. **Intervention:** No intervention. Records of people with SCI were retrospectively reviewed. **Outcome Measure:** FIM scores, complications.	1. Traumatic SCI group was significantly different from non-traumatic SCI group in: 2. Admission FIM scores were lower in traumatic (74.32) versus non-traumatic (89.68) SCI group (p=0.004). 3. FIM efficiency scores were higher in traumatic (0.15) versus non traumatic (0.07) SCI group (p=0.04). 4. No significant difference was seen between the two groups in: • Discharge FIM scores between the two groups (p=0.303). • LOS values (p=0.565). 5. Most common complication in non-traumatic group was UTI.
Yokoyama et al. (2006) Japan Case control $N_{Initial}$=34, N_{Final}=34	**Population:** *SCI due to aortic aneurysm:* Mean age=58.6yr; Level of injury: T=17; Severity of injury: AIS A=8, B=2, C=3, D=4. *Traumatic SCI:* Mean age=57.2yr; Level of injury: T=17; Severity of injury: AIS A=8, B=2, C=3, D=4. **Intervention:** No intervention. Data of patients with spinal cord injury associated with aortic aneurysm repair (SCI-AA) was compared to those with traumatic spinal cord injury (SCI). All patients had previously underwent a rehabilitation program consisting of 40 min of PT, 40 min of OT and 40 min of rehabilitation sports therapy per day for 5 days a wk. **Outcome Measures:** FIM, LOS, discharge, complications.	1. No significant difference was seen between the two groups in their LOS in the acute or rehabilitation hospital. 2. The two groups showed no difference in admission FIM scores; however, SCI group had significantly greater discharge FIM total scores (p=0.02), motor scores (p=0.03), total change (p=0.03), motor change (p=0.03) and efficiency (p<0.01). FIM cognitive score and cognitive change did not show significant differences. 3. Of all the medical complications and comorbidities only hypertension and cardiac disease were seen to be significantly higher in the SCI-AA group compared to the SCI group (p=0.01). 4. The amount of PT and OT was not significantly different between the two groups, while the SCI group was the only group receiving rehabilitation sports therapy.
McKinley et al. (2002) USA Case Control $N_{Initial}$=381, N_{Final}=183	**Population:** Non-traumatic SCI secondary to stenosis (n=81) versus traumatic SCI (n=102) within a single centre; Matching from N=381 sample on	1. As compared to those with trauma (before matching), those with stenosis were significantly (p<0.01): • Older (64.1 versus 44.4).

	paraplegia versus tetraplegia and completeness. **Intervention:** No intervention. Various outcomes associated with non-traumatic (stenosis) versus traumatic SCI rehabilitation were compared. Outcome measures were collected at admission to and discharge from rehabilitation. **Outcome Measures:** LOS, charges, Discharge rates to home, FIM (score, change and efficiency).	• More likely female (38.8 versus 21.2%) • More likely to have paraplegia (69.4% versus 45.5%) • More likely to be incomplete injury (AIS C or D) (100% versus 49.3%) 2. As compared to those with trauma (after matching), those with stenosis had significantly ($p<0.05$): • ↓ LOS (22.1 versus 32.2 days) • ↓ charges • ↑admission FIM and FIM motor scores • ↓ total and motor FIM change and FIM efficiency • No difference in discharge FIM totals • No difference in discharge destination.
McKinley et al. (2001) USA Case Control $N_{Initial}$=174, N_{Final}=174	**Population:** *Non-traumatic SCI (n=87)* from a single centre versus traumatic SCI (n=87) from the United States Model Systems database; Matched on level and completeness of lesion and age; 2/3rds 30-59yr, 1/3rd 60+ yr; 93% were admitted within 21 days of injury; 68% were paraplegic; AIS C 36%, AIS D 41%. Outcomes were collected at admission to and discharge from rehabilitation. **Intervention:** No intervention. Outcomes associated with non-traumatic versus traumatic rehabilitation. **Outcome Measures:** LOS, charges, motor FIM (score, change and efficiency).	1. As compared to those with trauma (after matching), those with non-traumatic SCI had: 1. ↓ rehabilitation LOS (22.46 versus 41.49days) ($p=0.000$) 2. ↓ overall charges ($p=0.003$) and ↓ daily charges ($p=0.019$) 3. No difference on motor FIM at admission and motor FIM efficiency with rehabilitation 4. ↓ motor FIM at discharge and ↓ motor FIM change 5. No difference in discharge destination.
McKinley et al. (1999) USA Case Control $N_{Initial}$=4035, N_{Final}=58	**Population:** Non-traumatic SCI secondary to neoplastic cord compression admitted over 5yr (within a single centre (n=29) versus traumatic SCI (n=29) from the United States Model Systems database matched by age, level of injury and AIS; Age =57.8 years; AIS A-D; C4-L2. **Intervention:** No intervention. Various outcomes associated with rehabilitation care of non-traumatic (neoplastic cord compression) versus traumatic SCI. Outcome measures were collected at admission to and discharge from rehabilitation. **Outcome Measures:** LOS, Discharge destination, FIM (total score, change and efficiency).	2. As compared to those with trauma (before matching), those with neoplastic cord compression were: • Older (57.8 versus 30.45). • More likely to have paraplegia (88.2% versus 52.5%) • More likely to be incomplete (88.2% versus 56.7%) 3. As compared to those with trauma (after matching), those with neoplastic cord compression: • Had ↓ LOS (25.17 versus 57.46 days) • Had ↓ motor FIM change • Had ↓ motor FIM scores at discharge • No different FIM efficiency • No different for discharge destination.
	Non-Traumatic	
Gupta et al. (2009) India Observational $N_{Initial}$=64, N_{Final}=64	**Population:** Mean age=30.64yr; Gender: males=28, females=36; Level of injury: paraplegia=67.2%, tetraplegia=32.8%; Duration of illness=7.1±9.2mo.	1. LOS was 55.8±40.9 days (Range 14-193 days). 2. BI scores showed significant functional recovery ($p=0.000$).

	Intervention: No intervention. Admission/discharge data for non-traumatic patients admitted for neurological rehabilitation from June 2005 to January 2008 was analyzed. **Outcome Measures:** Functional (BI) and neurological (AIS) outcomes and complication prevalence collected at admission and discharge.	3. AIS score showed significant neurological recovery during rehabilitation (p=0.001). 4. # of patients at AIS A went from 31.3% to 18.8%, AIS B from 20.3% to 7.8% and AIS C/D from 48.4%to 73.4% between admission and discharge. 5. 90% of patients reported at least one complication during rehabilitation. 6. Most common medical complications were UTI (50.0%), spasticity (35.9%), urinary incontinence (31.3%) and pressure ulcer (25.0%).
New et al. (2005) Australia Case Series $N_{Initial}$=70, N_{Final}=62	**Population:** *Non-traumatic SCI:* Mean age=69yr; Level and severity of injury: AIS B-D, tetraplegia=32.9%, AIS A, paraplegia=8.6%, AIS B-D=58.6%; Time since injury: <7 days=78.6%; Time to rehabilitation=30.9 days. **Intervention:** No intervention. Outcomes associated with non-traumatic SCI rehabilitation were assessed. **Outcome Measures:** Demographics, clinical characteristics, LOS, Discharge setting, level of lesion and AIS, FIM, mobility, bowel and bladder function. Collected at admission to and discharge from rehabilitation.	1. LOS =55.8 days (7-413 days). 2. ↑FIM motor scores during rehabilitation from 40.8 to 67.1, cognitive FIM showed no change due to initial ceiling effect. 3. 17.7% overall and 26.9% over the age of 70 were discharged to a nursing home. 4. Those subjects male, younger, more mobile, more independent bowel and bladder function and less severe AIS grades were more likely to be discharged home. 5. Major non-traumatic classifications were tumour (32.9%), degenerative (25.7%), vascular (14.3%) and other (27.1%).
Citterio et al. (2004) Italy Case Series $N_{Initial}$=323, N_{Final}=323	**Population:** *Non-traumatic SCI:* Mean age=55yr; Level of injury: cervical=72, thoracolumbar=251; Severity of injury: complete=79, incomplete=244; Etiology of injury: inflammatory=63, vascular=81, neoplastic=81, degenerative=60, other=38. **Intervention:** No intervention. Patients with non-traumatic SCI involved in rehabilitation were recruited and clinical data was analyzed. **Outcome Measures:** LOS, AIS grade, complications, discharge destination.	1. Mean LOS was 73.5 days; patients having complete cervical lesions had significantly (p<0.0026) longer mean LOS (107.9 days). 2. No significant difference was seen in LOS between men and women. 3. AIS grade B was significantly related to longer LOS (p<0.0001). 4. Living outside the rehabilitation centre district was related significantly to longer LOS (p<0.016). 5. Having at least 1 complication on admission was significantly related to longer LOS, pressure ulcers (p<0.03) or DVT (p<0.014). 6. 73% of patients were discharged home. 7. 20% of patients were transferred to other hospitals for specialized rehabilitation. 8. 3.3% of patients were admitted to nursing homes. 9. Discharge to home was predicting by marital status, incompleteness of lesion, clinical improvement, efficient bowel and bladder management, absence of pressure ulcers and longer LOS.
Van der Putten et al. (2001) England, UK Case Series $N_{Initial}$=100, N_{Final}=100	**Population:** *Non-traumatic SCI:* mean age=55yr; Gender: male=54%; Level of injury: cervical=49%, upper thoracic=21%, lower thoracic and	1. LOS =31.5 days (9-184 days). 2. Higher FIM motor score was associated with lower score on admission and reduced time between

	lumbar=22%; Time from onset to rehabilitation=4.8yr. **Intervention:** No intervention. Optimal outcomes were regressed against various factors associated with non-traumatic rehabilitation. **Outcome Measures:** Demographics, clinical characteristics, level of lesion and AIS, FIM motor score and change score. Collected at admission to and discharge from rehabilitation.	onset-admission (overall predictive model). 3. Age (i.e., younger), etiology (i.e., hereditary pathology) and lesion level (i.e., cervical) were individually associated with improved functional outcomes but did not improve prediction of overall model.
McKinley et al. (1996) USA Case Series $N_{Initial}$=32, N_{Final}=20	**Population:** Non-traumatic SCI secondary to neoplastic cord compression admitted over 5yr within a single centre; Mean age=64yr; Gender: male=18. Female=14. **Intervention:** No intervention. Outcomes associated with rehabilitation care were assessed. **Outcome Measures:** Medical complications, AIS, LOS, bladder function, FIM, Discharge destination. All collected at admission to and discharge from rehabilitation. Level of ambulation and dressing ability assessed at 3-15mo post-discharge.	1. LOS =27 days (7-54 days). 2. People showed significant↑in 9 FIM categories (0<0.005) associated with mobility and self-care during rehabilitation. 3. 11 individuals improved from AIS C to D at discharge. 4. 27/32 were discharged home, 4 transferred for medical reasons (and died within 2mo) and 1 died before discharge. 5. Of 20 people with assessed at 3-15 mo follow-up, 16 had maintained mobility and dressing function as compared to discharge. However, 12/20 had eventually died at a mean of 101 days post-discharge.
Traumatic		
Halvorsen et al., 2019 Norway Observational $N_{initial}$=349, N_{final}=349	**Population:** Mean age=47±19yr; Gender: male=265, female=84, Level of injury: paraplegia=146, tetraplegia=169; Severity of injury: AIS A-C=166, D=150, E=2, unknown=31. **Intervention:** No intervention. Retrospective analysis of epidemiological and demographic characteristics of individuals with SCI in Norway from 2012-2016. **Outcome measures:** Incidence of SCI, LOS, discharge location, cause of SCI, American Spinal Cord Injury Association Impairment Scale (AIS),	1. Most patients were discharged home following primary rehabilitation (68%). Falls were the main cause of SCI (47%), most often occurring during the weekend.
Franceschini et al., 2020 Switzerland Observational $N_{initial}$=510, N_{final}=497	**Population:** Mean age=50±20yr; Gender: male=402, female=95, Level of injury: not reported; Severity of injury: AIS A=173, B=78, C=122, D=104, E=2. **Intervention:** No intervention. Prospective analysis of patient characteristics on functional gains and discharge destination in patients with SCI admitted to rehabilitation. **Outcome measures:** SCIM, LOS, discharge destination.	1. The majority of the population was discharged home (72%), while a significant amount of those not returning home were transferred to a nonspecific rehabilitation facility (15%). 2. Individuals with fall-related injuries, severe SCI (AIS A, B, C tetraplegia), tracheal cannula or indwelling catheter on admission were less likely to be discharged home (OR 95%, CI 0.15 [0.06, 0.35]).
Dionne et al., 2020 Canada Case Control $N_{initial}$=193, N_{final}=193	**Population:** *Discharge Home (n=171):* Age <65=132, age>65=39; Gender: male=142, female=29, Level of injury: cervical=82, thoracic=81, lumbar=8; Severity of injury: complete=84, incomplete=87. *Not Discharged Home (n=22):* Age <65=14, age>65=8; Gender: male=16,	1. Of the total population, 11% failed to return home. 2. Failure to return home was associated with: o Longer acute LOS (p<.01) o Longer rehabilitation LOS (p=.02) o Living alone (p<.01)

	female=6, Level of injury: cervical=19, thoracic=3, lumbar=0; Severity of injury: complete=13, incomplete=9. **Intervention:** No intervention. Retrospective review of factors associated with success and failure to return home following inpatient intensive functional rehabilitation in patients with SCI. **Outcome measures:** discharge destination.	o Higher neurological level of injury (p=.02) o Having comorbidities (p=.02)

Discussion

Studies examining non-traumatic SCI typically make use of retrospective case series designs describing rehabilitation outcomes directly (Citterio et al., 2004; W. O. McKinley et al., 1996; Peter W New, 2005; P. W. New, 2006; van der Putten et al., 2001) or involve case control designs employing matching techniques to make comparisons with traumatic SCI while controlling for such things as age and level and completeness of injury (W. McKinley et al., 2008; W. O. McKinley, Huang, et al., 1999; W. O. McKinley et al., 2001; W. O. McKinley et al., 2002). As noted above, those with non-traumatic SCI were more likely to be older, female, have paraplegia and have an incomplete injury than those with traumatic SCI(W. O. McKinley et al., 1996; W. O. McKinley et al., 2001; W. O. McKinley et al., 2002; Peter W New, 2005). No difference in age, marriage, education, socioeconomic factors, length of stay, and functional outcome was reported for a case control analysis originating from India ((Gupta et al., 2008), N=76).

Patients with non-traumatic SCI (Citterio et al., 2004; W. O. McKinley et al., 1996) or traumatic SCI (Dionne, Richard-Denis, Lim, & Mac-Thiong, 2020; Marco Franceschini et al., 2020; Halvorsen et al., 2019b) were primarily discharged home after rehabilitation. Citterio et al. (2004) found that discharge to home was predicted by many factors including: marital status, completeness of injury, clinical improvement, efficient bowel and bladder management, and absence of pressure ulcers. Another important predictor was shown to be a longer length of stay. This was due to the finding that there is an increased probability of functional and neurological improvement after longer hospital stay. Dionne et al. (2020) found that failure to return home was predicted by living alone, higher a neurological level of injury and comorbidities. In contrast to Citterio et al. (2004), longer acute length of stay and longer rehabilitation stay were associated with failure to return home, suggesting more serious injury with greater length of stay.

Ones et al. (2007) and Yokoyama et al. (2006) showed no significant difference in length of stay between individuals with traumatic versus non-traumatic spinal cord injury. Conversely, when direct comparisons of traumatic and non-traumatic SCI of various etiologies have been conducted using matching procedures, it is clear that shorter rehabilitation LOS was seen for those with non-traumatic SCI (W. O. McKinley et al., 2001; Osterthun et al., 2009). In addition, this shorter LOS was associated with reduced hospital charges for both an overall and a per diem basis (W. O. McKinley et al., 2001). These findings were replicated with similar studies examining subsets of those with non-traumatic SCI including those with stenosis (W. O. McKinley et al., 2002) and those with neoplastic cord compression (W. O. McKinley, Huang, et al., 1999) although this was not the case for a review involving infection-based SCI (W. McKinley et al., 2008). Most of these findings have been established with data from the United

States Model Systems, although at least two reports from other jurisdictions have reported longer rehabilitation LOS (Peter W New, 2005; van der Putten et al., 2001).

None of the studies employing matching procedures noted differences in discharge destinations for those with non-traumatic SCI as compared to those with traumatic SCI (W. O. McKinley, Huang, et al., 1999; W. O. McKinley et al., 2001; W. O. McKinley et al., 2002). Although New et al. (2005) did note that among those with non-traumatic SCI, individuals who were male, younger, more mobile, more independent with bowel and bladder function and having less severe AIS grades were more likely to be discharged home. In addition, the relatively poor prognosis and low survival rate of those with neoplastic cord compression has specific implications for discharge disposition (W. O. McKinley et al., 1996) although no specific differences were noted in a matched comparison (W. O. McKinley, Huang, et al., 1999).

Comparing the rehabilitation of individuals with traumatic SCI with or without concomitant TBI, Bradbury et al (2008) reported no significant differences in LOS and FIM change score. However, the presence of dual diagnoses was deemed to result in clinically, but not statistically, significantly greater costs associated with the FIM change score.

All studies reviewed employed the FIM to assess the functional status of individuals and generally demonstrated improved function with rehabilitation. Typically, motor FIM scores were employed or in the event total FIM scores were used it was acknowledged that changes were due primarily to the motor FIM subscale given a ceiling effect associated with the cognitive FIM subscale (W. O. McKinley, Huang, et al., 1999; Peter W New, 2005). There was conflicting evidence in admission and discharge FIM scores between traumatic and non-traumatic SCI groups. A study by Ones et al. (2007) found patients with traumatic SCI had significantly lower admission FIM scores than those with non-traumatic SCI. However, other studies found no such trend (W. O. McKinley, Huang, et al., 1999; W. O. McKinley et al., 2001). FIM discharge scores were shown to be lower in the non-traumatic SCI population than traumatic (W. O. McKinley, Huang, et al., 1999; W. O. McKinley et al., 2001) while Ones et al (2007) showed no such difference. When examining only those with stenosis versus those with traumatic SCI, those with non-traumatic SCI had higher FIM scores on admission, similar scores on discharge, resulting in reduced change scores and lower efficiency (W. O. McKinley et al., 2002). On the other hand, those with neoplastic cord compression demonstrated similar FIM scores on admission, reduced scores on discharge, resulting in reduced change scores but no difference in efficiency (W. O. McKinley, Huang, et al., 1999).

McKinely et al. (1999) and McKinely et al. (2001) found no significant difference between traumatic versus non-traumatic SCI populations in FIM efficiency. However, Ones et al. (2007) showed a significantly higher FIM efficiency for persons with a traumatic as compared to a non-traumatic etiology. Given this and other conflicting findings in these studies it seems that it is especially important to appreciate the heterogeneity inherent in rehabilitation outcomes of persons with non-traumatic etiologies. In particular, much variation might be expected, especially between centre-based reports with relatively small sample sizes and which include various non-traumatic etiologies within a single non-traumatic grouping. Future research should focus on large scale, case control methodologies employing subject matching strategies that control for potential confounding variables or that examine the effect of potential mediating variables. It is also important to consider logical subgroups based on specific etiologies of non-traumatic SCI.

Van der Putten (2001) assessed a variety of factors using multiple linear regression techniques in order to predict those most associated with increases in FIM motor scores during rehabilitation. They included 100 consecutively admitted patients with non-traumatic SCI with rehabilitation periods of more than 1 week. The primary factors associated with improved motor FIM scores accounting for 54% of the variance were having a lower score on admission and reduced time between symptom onset to admission. Age, specific diagnostic subgroup (i.e., space-occupying, vascular, spondylosis, inflammation or hereditary) or lesion level did not improve the prediction significantly.

In line with the topic of this discussion, guidelines established by Rapidi and colleagues (2018) for Physical and Rehabilitation Medicine suggest that therapeutic exercise programs in SCI are prescribed and adapted to SCI persons' needs, according to the neurological level of injury, age, and comorbidity.

Conclusions

There is level 3 evidence (from five case control studies; (W. McKinley et al., 2008; W. O. McKinley, Huang, et al., 1999; W. O. McKinley et al., 2001; W. O. McKinley et al., 2002; Yokoyama et al., 2006) that those with non-traumatic SCI have generally reduced rehabilitation LOS and reduced hospital charges.

There is level 3 evidence (from one case control study; (Dionne et al., 2020)), level 4 evidence (from two case series; (Citterio et al., 2004; W. O. McKinley et al., 1996)) and level 5 evidence (from two observational studies; (Marco Franceschini et al., 2020; Halvorsen et al., 2019a) that those with non-traumatic SCI have similar discharge destinations as compared to those with traumatic SCI.

There is conflicting level 3 evidence (from seven case control studies; (Gupta et al., 2008; W. McKinley et al., 2008; W. O. McKinley et al., 2001; W. O. McKinley et al., 2002; Ones et al., 2007; Yokoyama et al., 2006) that individuals with non-traumatic SCI may experience less functional gains than those with traumatic SCI, although many studies are comparing persons with different etiologies of non-traumatic SCI.

There is level 3 evidence (from one case control study; (Bradbury et al., 2008) that individuals with traumatic SCI with or without concomitant traumatic brain injury have similar LOS and achieve similar FIM motor scores, but associated costs were higher in those with dual diagnosis.

There is level 4 evidence (from one case series study; (van der Putten et al., 2001) that those with non-traumatic SCI are more likely to be older, female, have paraplegia and have an incomplete injury as compared to those with traumatic SCI.

There is conflicting level 4 evidence (from four case series; (Citterio et al., 2004; Gupta et al., 2009; W. O. McKinley et al., 1996; Peter W New, 2005) that patients with non-traumatic SCI recover significant neurological and functional improvements following rehabilitation.

In general, individuals with non-traumatic SCI may have reduced LOS and less functional improvement with rehabilitation as compared to those with traumatic SCI. Additional studies that better control for non-traumatic subtypes are required.

5.4 Gender

With respect to gender effects, studies investigating rehabilitation outcomes among women have focused on long-term psychosocial outcomes associated with issues such as marriage or motherhood or issues associated with community and vocational reintegration (Michael J DeVivo, La Verne, Richards, & Go, 1995; J Stuart Krause, Sternberg, Maides, & Lottes, 1998; Shackelford, Farley, & Vines, 1998; Westgren & Levi, 1994). However, there has been little research concerning the influence of gender on rehabilitation.

Table 8. Effect of Gender on Rehabilitation Outcomes

Author Year **Country** **Research Design** **PEDro Score** **Total Sample Size**	**Methods**	**Outcome**
Franceschini et al., 2020 Switzerland Observational $N_{initial}$=510, N_{final}=497	**Population:** Mean age=50±20yr; Gender: male=402, female=95, Level of injury: not reported; Severity of injury: AIS A=173, B=78, C=122, D=104, E=2. **Intervention:** No intervention. Prospective analysis of patient characteristics on functional gains and discharge destination in patients with SCI admitted to rehabilitation. **Outcome measures:** SCIM.	1. Female individuals were less likely to improve on the SCIM.
Gupta et al. (2008) India Case Control $N_{Initial}$=76, N_{Final}=76	**Population:** *Traumatic (n=38):* Mean age=32.86yr; Gender: males=34, females=4. *Non-traumatic (n=38):* Mean age=31yr; Gender: males=16, females=22 **Intervention:** Admission/discharge data from all surviving non-traumatic and traumatic spinal cord lesion (SCL) patients in a neurological rehabilitation facility was assessed over a 2yr period. **Outcome Measures:** LOS, BI, AIS collected at admission and discharge.	1. The traumatic SCL group had significantly more males than females (p<0.05) and was not significantly different in age, marriage, education or socioeconomic factors.
McKinley et al. (2008) USA Case control $N_{Initial}$=594, N_{Final}=594	**Population:** Infection related spinal cord disease (*IR-SCD):* Mean age=53.3yr; Gender: males=64.7%; Level of injury: paraplegia=74%. Traumatic SCI: Mean age=40.4yr; Gender: males=83.8%; Level of injury: paraplegia=49% **Intervention:** No intervention. Data was reviewed of individuals diagnosed with infection related SCD against those with traumatic SCI. **Outcome Measures:** Acute and rehabilitation hospital LOS, FIM motor scores, FIM motor change, FIM motor efficiency, AIS change.	1. When compared with traumatic SCI (n=560), patients with IR-SCD comprised significantly less of the SCI/D rehabilitation admissions (3% versus 61%), were older (53 versus 40yr), and more often female (35% versus 16%). Injuries were more commonly located in the thoracic region (48% versus 38%).
Ronen et al. (2004) Israel Case Control $N_{Initial}$=1401, N_{Final}=1401	**Population***: Traumatic Spinal Cord Injury (TSCI; n=250):* Mean age=34.5±15.3yr; Gender: males=5, females=0; Level of injury: cervical=37%. Thoracic=32%, lumbosacral=31%; Severity of injury: Frankel grade A=74, B=42, C=100, D=34; Time since injury=59 days. *Non-Traumatic Spinal Cord Injury (NTSCI; n=1117):* Mean age=47.1±16.8yr; Gender: male=9, female=3; Level of injury: cervical=32%, thoracic=44%, lumbosacral=24%; Severity of	1. The mean LOS was 239±168 for individuals with TSCI and 106±137 for individuals with NTSCI. 2. SCI severity, etiology and decade of admission to rehabilitation were significantly associated with LOS (p<0.001). 3. SCIM II gains were positively associated with LOS, when LOS

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
	Injury: Frankel grade A=32, B=146, C=506, D=433. Time since injury=51mo. **Intervention:** No intervention. Retrospective analysis of the factors that influence LOS. **Outcome Measures:** LOS, SCI etiology, SCI severity, decade of admission to rehabilitation, and Spinal Cord Independence Measure II (SCIM II).	was short (<70 days; r=0.81-0.82, p<0.001). 4. Male patient LOS (147±183) was significantly higher than female patient LOS (105±82) (p<0.02).
Scivoletto et al. (2004) Italy Case Control $N_{Initial}$=281, N_{Final}=281	**Population:** SCI: Mean age=50.4yr; Gender (traumatic): males=82, females=23; Gender (non-traumatic): males=101, females=75; Level of injury: cervical=78, thoracic=152, lumbar=51; Severity of injury: AIS: A=84, B=18, C=127, D=52. **Intervention:** No intervention. Those with SCI were retrospectively evaluated to examine sex-related differences. **Outcome Measures:** Admission scores, discharge scores, length of stay, efficiency.	1. No significant difference was seen between males and females in all the outcome measures including: • Admission age. • Admission scores. • Discharge scores. • Length of stay. • Efficiency scores. 2. Female patients than male patients had a lower frequency of: • Traumatic lesions. • Complications at admission. 3. Females had a higher frequency of incomplete lesions than males.
McKinley et al. (2002) USA Case Control $N_{Initial}$=381, N_{Final}=183	**Population:** Non-traumatic SCI secondary to stenosis (n=81) versus traumatic SCI (n=102) within a single centre; Matching from N=381 sample on paraplegia versus tetraplegia and completeness. **Intervention:** No intervention. Various outcomes associated with non-traumatic (stenosis) versus traumatic SCI rehabilitation were compared. Outcome measures were collected at admission to and discharge from rehabilitation. **Outcome Measures:** LOS, charges, Discharge rates to home, FIM (score, change and efficiency).	1. As compared to those with trauma (before matching), those with stenosis were significantly (p<0.01): • Older (64.1 versus 44.4). • More likely female (38.8 versus 21.2%) • More likely to have paraplegia (69.4% versus 45.5%) • More likely to be incomplete injury (AIS C or D) (100% versus 49.3%)
Greenwald et al. (2001) USA Case Control $N_{Initial}$=1074, N_{Final}=1074	**Population:** Traumatic SCI from United States Model Systems database; matched male versus female by level of function, AIS and age: 50% were 18-34yr, 42% were 36-64yr and 8% were >64yr old; Level of injury: tetraplegia, paraplegia; Severity of injury: AIS A-D; Time to rehabilitation: 86% were admitted to Model systems within 21 days post-injury. **Intervention:** No intervention. Outcomes associated with inpatient acute and rehabilitation care focusing on gender effects were assessed. **Outcome Measures:** Length of Stay, Charges, ASIA motor index total score, FIM motor score, FIM motor change scores, FIM motor efficiency scores, and medical complications. Collected at admission to acute care and admission to and discharge from rehabilitation.	1. No significant differences were seen for acute care or rehabilitation Length of Stay or charges between males and females. 2. No significant differences were seen in discharge destinations between males and females. 3. No significant differences were seen in admission, discharge, or change scores for both functional (i.e., FIM) and neurological (i.e., AIS) assessments between males and females. 4. Gender differences in the development of complications during rehabilitation, notably, pressure sores (p<0.001) and DVTs (p=0.003) were more likely in men.

Author Year Country Research Design PEDro Score Total Sample Size	**Methods**	**Outcome**
		5. Younger patients had better functional outcomes than older patients with significantly higher FIM motor scores at discharge. 6. Older patients had significantly greater ASIA motor scores on admission and discharge than middle-aged patients, who had significantly greater scores than younger patients.
Furlan et al. (2005) Canada Case Series $N_{Initial}$=55, N_{Final}=55	**Population:** *Males (n=38):* Mean age=51.5yr; Level of injury: C1 to C7; Severity of injury: AIS: A-D; Etiology of injury: falls=36.8%, motor vehicle accidents=31.6%, diving accident =7.9%, other=23.7% *Females (n=17):* Mean age=63.2 yr; Level of injury: C1 to C7; Severity of injury: AIS: A-D; Etiology of injury: falls=64.7%, motor vehicle accidents=23.5%, diving accident=11.8%. **Intervention:** No intervention. Those with acute cervical traumatic SCI were retrospectively analyzed to assess gender differences. **Outcome Measures:** Secondary complications, AIS.	1. No significant differences were seen between the two sexes was seen in: • Secondary complications. • Improvement in AIS scores. 2. Women had significantly higher rate of psychiatric complications (p=0.054) and deep venous thrombosis (p=0.092) then men.
New et al. (2005) Australia Case Series $N_{Initial}$=70, N_{Final}=62	**Population:** *Non-traumatic SCI:* Mean age=69yr; Level and severity of injury: AIS B-D, tetraplegia=32.9%, AIS A, paraplegia=8.6%, AIS B-D=58.6%; Time since injury: <7 days=78.6%; Time to rehabilitation=30.9 days. **Intervention:** No intervention. Outcomes associated with non-traumatic SCI rehabilitation were assessed. **Outcome Measures:** Demographics, clinical characteristics, LOS, Discharge setting, level of lesion and AIS, FIM, mobility, bowel and bladder function. Collected at admission to and discharge from rehabilitation.	1. Those subjects' male, younger, more mobile, more independent bowel and bladder function and less severe AIS grades were more likely to be discharged home.
Sipski et al. (2004) USA Case Series $N_{Initial}$=14433, N_{Final}=14433	**Population:** SCI: Mean age=31.8 yr; Gender: males=11762, females=2671; Etiology of injury: vehicular collision=6092, violence=2888, diving/other sports=1550, falls=2807, other=1096. **Intervention:** No intervention. Patient data was retrospectively analyzed to assess gender differences in patients with SCI. **Outcome Measures:** AIS, FIM scores, motor score improvement.	1. Completeness of injury was significantly higher in: • Males than females (p=0.007). • Younger females (younger than 40yr) than older females (older than 50yr), p<0.001. 2. AIS motor scores from admission to 1yr post injury, were significantly higher for women than men with complete (p=0.035) or incomplete (p=0.031). 3. At 1yr post injury, improvement of motor scores on the left side was significantly greater for women than for men with complete injuries

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
		(p=0.018) and incomplete injuries (p=0.016). 4. Women with motor incomplete tetraplegia at C1-4 levels had higher discharge FIM motor scores than men. However, motor complete men had higher discharge FIM scores than motor complete women.
Pollard & Apple, (2003) USA Case Series $N_{Initial}$=412, N_{Final}=95	**Population:** Mean age=not reported; Gender: not reported; Level and severity of injury: incomplete tetraplegia; Time since injury=not reported. **Intervention:** No intervention. Retrospective review of patients with incomplete tetraplegia to determine what patient characteristics, injury variables and management strategies are associated with improved neurological outcomes. **Outcome Measures:** Motor score, motor level sensory score, sensory level and ASIA grade.	1. Neurological recovery was not significantly related to gender (p>0.05).
Krause et al. (2006) USA Observational $N_{Initial}$ =1342, N_{Final}=1278	**Population:** Mean age=41.6yr; Gender & Race: 75% white, 74% male, 56% white male, 21% white female, 18% African American men, 5% African American females; Injury Duration: Mean=9.7yr; Level of injury: cervical=55%: Injury severity: no sensation or movement=29.4%, sensation but no movement=28.5%, movement but not ambulation=20.8%, useful function including ambulation =21.5%. **Intervention:** No intervention. Cross-sectional survey to examine the effect of race and gender on health status and healthcare utilization and the mediating effects of education and income. **Outcome Measures:** Three general health indicators from the Behavioral Risk Factor Surveillance (self-rated health, days of poor physical health, days of poor mental health) and 3 healthcare utilization measures (number of hospitalizations, days of hospitalizations, number of doctor visits).	1. Differences in gender were seen in the significantly higher rates of non routine physician visits by females than males, but not for the other general health or healthcare utilization indicators. 2. After accounting for mediators, the gender differences remained significantly different for higher rates of non routine physician visits by females than males, however this gender effect was substantially less than that evident with the mediating variables of income and education.

Discussion

Greenwald et al. (2001) employed a mixed, block design, matching male and female subjects to control for covariant effects of injury characteristics (level and AIS) and age at injury. They retrospectively analyzed 1,074 subjects over a 10-year period from 1988 to 1998 by using United States Model Systems data culled from 20 different SCI centres over a variety of geographic regions. In general, there were no significant differences between males and females for rehabilitation outcomes including discharge disposition, LOS, FIM motor scores (including change scores and efficiencies) or ASIA motor scores. This is in contrast to an observational study which found that females were less likely to improve on functional measures (Marco Franceschini et al., 2020). There were also no reported gender-related differences for the incidence of most medical complications encountered during rehabilitation stay including pneumonia, autonomic dysreflexia, pulmonary embolism, cardiac arrest, kidney calculi or gastrointestinal hemorrhage. However, men did have significantly higher rates for pressure sores although the authors reported that these differences were not robust and did not result in increased stays, charges or lower functional outcomes.

One case control study conducted by Ronen et al. (2004) found that males experience greater rehabilitation LOS when compared to females. However, this may be related to injury type and severity rather than gender. Further analysis of this trend is necessary.

In one case series, New et al. (2005) found that males were more likely to be discharged home. Although, these patients were also younger, more mobile, independent and less severely impaired.

Studies have found mixed evidence for gender-related differences in the incidence of deep vein thrombosis in the SCI population. Greenwald et al. (2001) demonstrated a significantly higher rate of deep vein thrombosis in men while Furlan et al. (2005) found a higher rate in women.

The prevalence of psychiatric complications was found to be higher in women than men in the SCI population (Furlan et al., 2005). After SCI, women in the chronic stage had more symptoms of depression than men in the chronic stage (Furlan et al., 2005) but Krause et al. (2006) did not report a gender difference with regard to number of days adversely impacted by poor mental health in women.

Pollard and Apple (2003) demonstrated that, as a whole no gender-related differences were seen in neurological recovery. However, in contrast to Pollard and Apple (2003), Greenwald et al. (2001) and Furlan et al. (2005) studies, Sipski et al. (2004) found women's ASIA motor scores were significantly higher than men's 1 year after injury. Also, in contrast to Greenwald et al. (2001), Sipski et al. (2004) found men showed significantly greater FIM motor improvement than women by discharge. Additionally, there is some evidence to suggest that males experience more traumatic injuries than females as demonstrated by the findings of Gupta et al. (2008) and McKinley (W. McKinley et al., 2008; W. O. McKinley et al., 2002).

Overall, it appears there is only minimal evidence that suggests gender differences for most rehabilitation outcomes. Of note, the study with the strongest design (i.e., case control with matching to limit potential confounding) found few gender-related differences (Greenwald et al., 2001). Of note, Krause et al. (2006) found a significant difference between men and women in only one (i.e., non-routine physician visits) of six measures addressing healthcare utilization and general health status. Upon analysis of the effect of the potential mediating variables of education and income it was found that these had substantially more impact on the likelihood of women having more nonroutine physician visit than did the role of gender differences.

Conclusions

There is conflicting level 3 (from three case control studies; (Greenwald et al., 2001; Ronen et al., 2004); Scivoletto, 2004 #64}, level 4 evidence (from four case studies; (Furlan et al., 2005; Peter W New, 2005; Pollard & Apple, 2003; Sipski et al., 2004) and level 5 evidence (from one observational study; (Marco Franceschini et al., 2020) that there is no difference with respect to gender on discharge destination, rehabilitation LOS and neurological or functional outcomes associated with rehabilitation.

There is conflicting level 3 (from four case control studies; (Gupta et al., 2008; W. McKinley et al., 2008; W. O. McKinley et al., 2002; Giorgio Scivoletto et al., 2004) and level 4 evidence (from one case series; (Sipski et al., 2004) that male patients experience more traumatic and incomplete injuries and of those that are female, younger females experience more complete injuries.

There is conflicting level 4 evidence (from one case series; (Furlan et al., 2005) that women may experience more complications at admission, psychiatric complications and deep vein thrombosis than men.

There is level 5 evidence (from one observational study; (J. S. Krause et al., 2006) that female patients utilize more non routine physician visits than males.

There are no significant effects of gender on rehabilitation outcomes.

5.4 Socioeconomic Status

Very little research exists examining the effect of socioeconomic status (SES) on rehabilitation outcomes in SCI. However, those with a greater SES may experience enhanced well-being, participation and employment (Amanda L Botticello, Chen, Cao, & Tulsky, 2011; A. L. Botticello, Chen, & Tulsky, 2012). As discussed previously, SES may have more of an impact on rehabilitation outcomes in relation to education and income than race. In this sense, understanding the role of SES in access to continuing care is important to improve rehabilitation outcomes and inform health policy within SCI populations, particularly for individuals with low SES.

Table 9. Effect of Socioeconomic Status on Rehabilitation Outcomes

Author, Year Country Research Design PEDro Score Total Sample Size	**Methods**	**Outcome**
Chhabra & Bhalla, (2015) India Observational $N_{Initial}$=150, N_{Final}=150	**Population:** *Below poverty line (BPL, n=30):* mean age=30.6±10.7yr; Gender: male=30, female=0; Level of SCI: tetraplegic (T)=15, paraplegic (P)=15. *Upper-lower (n=16):* mean age=24.75±5.2yr; Gender: male=16, female=0; Level of SCI: T=5, p=11. *Lower-middle (n=26):* mean age=30.75±9.8yr; Gender: male=24, female=2; Level of SCI: T=18, p=8. *Upper-middle (n=38):* mean age=29.58±10.4yr; Gender: male=22, female=16; Level of SCI: T=9, p=29. *Upper (n=40):* mean age=31.98±12.1yr; Gender: male=28, female=12; Level of SCI: T=25, p=15. **Intervention:** No intervention given. Those with SCI admitted to a SCI centre were classified by socioeconomic status (SES) using the Kuppuswamy scale and completed a custom questionnaire.	1. CIQ scores were significantly greater in upper to upper middle SES groups (p<0.05). 2. A statistically significant difference in level of difficulty accessing SCI management perceived by the patient between different SES groups (p<0.05). 3. Severe difficulties due to financial constraints were reported by unaided upper lower, lower middle, and most of the upper middle SES groups. 4. Upper SES group were the only to report no difficulty in accessing SCI care.

	Outcome Measures: Questionnaire determining difficulties in accessing SCI care, Community Integration Questionnaire (CIQ).	
Gupta et al. (2008) India Case Control $N_{Initial}$=76, N_{Final}=76	**Population:** *Traumatic (n=38):* Mean age=32.86yr; Gender: males=34, females=4. *Non-traumatic (n=38):* Mean age=31.10; Gender: males=16, females=22 **Intervention:** Admission/discharge data from all surviving non-traumatic and traumatic spinal cord lesion (SCL) patients in a neurological rehabilitation facility was assessed over a 2yr period. **Outcome Measures:** LOS, BI, AIS collected at admission and discharge.	1. The traumatic SCL group was not significantly different in age, marriage, education or socioeconomic factors.

Discussion

Gupta et al. (2008) compared socioeconomic status among individuals with traumatic and non-traumatic SCI. They found no significant differences in SES between groups, suggesting that type of injury is independent of SES. Although, type of injury may be independent of SES, Chhabra and Bhalla (2015) found that financial constraints affect all components of SCI management across all SES groups except for those with the highest SES. However, the generalizability of this study to populations outside of India needs to be investigated in further studies. Despite this, SES is an important factor to consider when determining management strategies beyond outpatient rehabilitation.

Conclusions

There is level 3 evidence (from one case control study; (Gupta et al., 2008) that socioeconomic status has no effect on type of injury.

There is level 5 evidence (from one observational study; (Chhabra & Bhalla, 2015) that financial constraints experienced by patients affect access to SCI care in all socioeconomic status groups, except those with the greatest socioeconomic status.

> Low socioeconomic status may affect access to comprehensive SCI care and in turn, rehabilitation outcomes.

5.5 Race

Studies of the effects of race on rehabilitation outcomes have generally been limited to retrospective evaluations of the differences between whites and African Americans (Meade, Cifu, Seel, McKinley, & Kreutzer, 2004; Putzke, Hicken, & Richards, 2002). Similar to studies on gender, investigations on race have focused more on vocational issues and satisfaction with life (James, DeVivo, & Richards, 1993; J Stuart Krause, 1998; J Stuart Krause et al., 1998; Meade, Lewis, Jackson, & Hess, 2004) than rehabilitation.

Table 10. Effect of Race on Rehabilitation Outcomes

Author, Year Country Research Design PEDro-Score Total Sample Size	Methods	Outcome
Krause et al. (2006) USA Case Series $N_{Initial}$=1342, N_{Final}=1278	**Population:** Mean age=41.6yr; Gender & Race: 75% white, 74% male, 56% white male, 21% white female, 18% African American men, 5% African American females; Injury Duration: Mean=9.7yr; Injury level: Cervical=55%: Injury severity: No sensation or movement=29.4%, sensation but no movement=28.5%, movement but not ambulation=20.8%, useful function including ambulation=21.5%. **Intervention:** No intervention. Cross-sectional survey to examine the effect of race and gender on health status and healthcare utilization and the mediating effects of education and income. **Outcome Measures:** Three general health indicators from the Behavioural Risk Factor Surveillance (self-rated health, days of poor physical health, days of poor mental health) and three healthcare utilization measures (number of hospitalizations, days of hospitalizations, number of doctor visits).	1. A significant difference was seen based on race in 3 of 6 outcomes: African Americans had more days in poor health, more hospitalizations in the past year and more days hospitalized. 2. Inclusion of mediators in MANOVA analysis indicated that variables of income and education accounted for much more of the variance seen for these variables of general health and healthcare utilization than did race.
Meade et al. (2004) USA Case Control $N_{Initial}$=628, N_{Final}=628	**Population:** Traumatic SCI from United States Model Systems database; matched white versus African American subjects matched by level of function, ASIA Impairment Scale, age and primary care sponsor: Mean age=34.2yr; Gender: males=84.2%, females=14.7%; Level of injury: paraplegia, tetraplegia; Severity of injury: AIS: A-D. **Intervention:** No intervention. Various outcomes associated with acute inpatient and rehabilitation care focusing on race effects by comparing outcomes of African Americans and whites. **Outcome Measures:** AIS motor index scores, FIM motor score, Medical complications, discharge disposition, medical procedures and medical management. Collected at admission to acute care and admission to and discharge from rehabilitation.	1. No significant differences between white versus African American races for AIS and FIM motor index scores. 2. No significant differences for discharge disposition ($p=0.622$). 3. African Americans were more likely to be injured as a result of violence and whites were more likely to be injured in MVCs. 4. African Americans were significantly more likely to receive laparotomies ($p<0.001$) and be catheter free in comparison to Caucasians. 5. Whites were more likely to receive spine surgeries ($p<0.001$) and have more suprapubic cystomies in comparison to African Americans. 6. No significant differences between racial groups in the occurrence of medical complications during either acute care or rehabilitation.
Pollard & Apple, (2003) USA Case Series $N_{Initial}$=412, N_{Final}=95	**Population***:* Mean age=not reported; Gender: not reported; Level and severity of injury: incomplete tetraplegia; Time since injury=not reported. **Intervention:** No intervention. Retrospective review of patients with incomplete tetraplegia to determine what patient characteristics, injury variables and management strategies are associated with improved neurological outcomes.	1. Neurological recovery was not significantly related to race ($p>0.05$).

Author, Year Country Research Design PEDro-Score Total Sample Size	Methods	Outcome
	Outcome Measures: Motor score, motor level sensory score, sensory level and ASIA grade.	
[Putzke et al.](#) (2002) USA Case Control Study 1: $N_{Initial}$=2438, N_{Final}=374 Study 2: $N_{initial}$=3301, N_{Final}=316	**Population:** *Study 1:* Mean age=34.8yr (white) & 35.3yr (African American); Gender (both groups): males=90%, females=10%. *Study 2:* Mean age=37.7yr (white) & 37.8yr (African American): Gender (both groups): males=93%, females=7%. **Intervention:** No intervention. Race effects on various outcomes associated with integrated acute and rehabilitation care (study 1) or long-term (study 2) studied by comparing results between whites and African Americans. **Outcome Measures:** *Study 1:* FIM motor and efficiency scores, length of stay, discharge destination, medical complications, charges. *Study 2:* FIM motor and efficiency scores, CHART, Satisfaction with Life Scale (SWLS), SF-12 (measured the individual's perception of his/her health status), medical complications and number of hospitalizations. All collected at admission, discharge or at annual follow-up (Study 2 only).	*Study 1* 1. Significant differences between race were not found relating to any of the outcome measures including FIM, Length of Stay (acute or rehabilitation care), Discharge destination and charges (p>0.05). 2. The 2 groups were significantly different (p<0.001) on numerous other demographic and injury-related factors including age, education, gender, race, marital and occupational status, lesion level, and injury duration. *Study 2* 3. No significant differences were seen with SWLS, SF-12 and CHART (p=0.25). 4. None of the medical outcome variables differed significantly (p>0.05) with race, including days rehospitalized and number of rehospitalizations in the previous year, impairment level, and total medical complications. 5. Despite non-significant results with multivariate analyses, univariate analyses were also conducted and were generally non-significant except that whites reported less handicap on the CHART mobility subscale (p=0.03). 6. As with Study 1, both groups differed significantly on numerous demographic and injury-related factors (p<0.001).
[Eastwood et al.](#) (1999) USA Case Series $N_{Initial}$=5180, N_{Final}=3904	**Population***:* Age: <21=882, 21-30=1182, 31-40=803, 41-50=484, >50=552, unknown=1; Gender: males=3157, females=747; Level and severity of injury: paraplegia-incomplete=777, paraplegia-complete=1202, tetraplegia-incomplete=1065, tetraplegia-complete=782, unknown=78; Time since injury=not reported. **Intervention:** No intervention. Retrospective chart review of patients discharged between 1990 and 1997 with traumatic SCI to determine predictors of acute rehabilitation length of stay and their association with medical and social outcomes. Outcomes were assessed at rehabilitation discharge and 1yr following injury. **Outcome Measures:** Rehabilitation LOS, age, race, method of bladder management,	1. Caucasians experienced significantly longer rehabilitation LOS than African Americans (p<0.05).

Author, Year Country Research Design PEDro-Score Total Sample Size	Methods	Outcome
	tetraplegia, education, marital status, discharge disposition, 1yr presence of pressure ulcers, rehospitalization, place of residence, days per week out of residence.	

Discussion

Similar case control designs employing matched groups of Caucasians versus African Americans from the United States Model Systems database have also been employed to examine race effects on rehabilitation outcomes. Putzke et al. (2002) matched race groups according to age, education, gender, occupational status, impairment level, etiology, primary sponsor of care and geographic region whereas Meade et al. (2004) matched according to level of injury, AIS, age and primary sponsor of care. By controlling for all these variables, these authors were able to establish that race acts more as a proxy variable than a predictor of outcomes (Putzke et al., 2002). For example, differences did exist in a wide variety of demographic, rehabilitation outcomes and medical complications for African Americans versus Caucasians but these were generally accounted for by socio-demographic and etiological differences associated with these groups (Meade, Cifu, et al., 2004; Putzke et al., 2002). For example, African Americans were significantly more likely to be injured as the result of violence and have 11th grade education or less while Caucasians were more likely injured as a result of motor vehicle crashes and had high school education or more (Meade, Cifu, et al., 2004; Putzke et al., 2002). It is likely that these etiological and socio-demographic variations have far more to do with differences seen in rehabilitation outcomes than race. In support of this, Pollard and Apple (2003) found that neurological recovery was not affected by race.

Krause et al. (2006) observed that, post-discharge, African Americans in a Southeastern United States SCI population reported a greater number of poor health days, more hospitalizations, and a greater number of days hospitalized. However, by conducting an analysis of the effect of the potential mediating variables of education and income it was found that these had substantially more impact on these findings than did the effect of race. In contrast, Eastwood and colleagues (1999) found that African Americans experienced shorter rehabilitation LOS than Caucasians. Although, this difference was not further explored in the study, it may be attributable to variation in injury severity.

Conclusions

There is level 3 (from two case control studies and three case series; (Eastwood et al., 1999; J. S. Krause et al., 2006; Meade, Cifu, et al., 2004; Pollard & Apple, 2003; Putzke et al., 2002) that there is no difference with respect to race (Caucasians versus African-American) on rehabilitation LOS and neurological or functional outcomes associated with rehabilitation that are not otherwise explained by socio-demographic or etiological differences.

Neither gender nor race effects have been demonstrated definitively for discharge destination, complications, rehabilitation LOS and neurological or functional status in patients with SCI.

6.0 Specialized versus General SCI Units (Acute Care)

Donovan et al. (1984) contend that best practice for SCI care consists of every individual with SCI being admitted to an integrated, comprehensive system where expertise, facilities and equipment are focused on optimal patient care and cost effectiveness. Alternatively, Bedbrook and Sedgley (1980) recommend piecemeal care for those with SCI characterized by "the occasional patient being treated by the occasional doctor." In practice, care provided by most SCI centres likely falls somewhere in between these extremes of ideal, specialized care and non-specific, general care. The present section outlines the studies that are focused on examining the hypothesis that care provided in specialized SCI centres is more efficient and effective than that delivered at general centres. Although the majority of these studies were conducted within rehabilitation centres, this section includes studies that evaluated the impact of specialist SCI care that is delivered in the acute care following SCI and/or in post-acute care inpatient rehabilitation.

Table 11. Effect of Specialized versus General SCI Units

Author Year Country Research Design PEDro Score Total Sample Size	**Methods**	**Outcome**
Chang et al., 2020 China Pre-Post Test $N_{initial}$=455, N_{final}=455	**Population:** Mean age=46.2±13.1yr; Gender: male=290, female=165, Level of injury: cervical=135, thoracic=241, lumbosacral=79; Severity of injury: not reported. **Intervention:** Specialized 45d inpatient rehabilitation program for patients with chronic SCI. **Outcome measures:** Basic life skills score, motor score, cognition and emotion score.	1. The median total basic life score increased by 14.1%, while motor score improved by 14.8% following intervention (p<.01). 2. The cognition and emotion score did not change following intervention. 3. The greatest improvements in basic life skills were: o Toileting (40%) o Bath transfer (40%) 4. Social and basic life skill application in family and social life significantly improved (p<.01).
Pattanakuhar et al., 2019 Thailand Cohort $N_{initial}$=234, N_{final}=234	**Population:** *SCI Specialized Facility (n=167):* Mean age=50.6±16.3yr; Gender: male=110, female=57, Level of injury: paraplegia=46, tetraplegia=121; Severity of injury: AIS A-C=58%, D=42%. *Non-SCI Specialized Facility (n=67):* Mean age=43.1±18.2yr; Gender: male=45, female=22, Level of injury: paraplegia=39, tetraplegia=28; Severity of injury: AIS A-C=83%, D=17%. **Intervention:** No intervention. Prospective comparison of functional outcomes in patients admitted to specialized or non-specialized rehabilitation facilities.	1. Patients discharged from specialized facilities demonstrated a greater improvement in SCIM score than those from non-specialized facilities (p=.003). 2. Specialized rehabilitation facilities were an independent predictive factor of SCIM improvement at discharge (p=.008).

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
	Outcome measures: Spinal Cord Independence Measure (SCIM).	
McKechnie et al. (2019) Australia Cohort N=3714	**Population:** 2007 (n=856): specialist=334, non-specialist=522; 2010 (n=808): specialist=312, non-specialist=496; 2013 (n=972): specialist=548, non-specialist=424; 2016 (n=1078): specialist=533, non-specialist=545 **Treatment:** Comparison of patients in specialized versus non-specialized rehabilitation units over 10-year period. **Outcome Measures:** Patient demographics, onset from injury, LOS, FIM **Chronicity:** Inpatient rehabilitation	1. Across time-groups, there were a greater proportion of those with SCI in non-specialist units. 2. Specialist units admit more males and the average age is lower. 3. Onset from injury and rehab LOS were longer for specialist units. 4. Total LOS for SCI in specialized units was 90 days, nearly double non-specialized units. 5. Mean FIM admission was lower in specialized unit versus non-specialized. 6. Patients admitted to specialized units had higher burden of care at admission and greater functional outcomes (absolute functional gain)
Cheng et al. (2017) Canada Cohort N=1599	**Population:** RHSCIR (n=1138): median age=47y (IQR: 33); Gender: male=79%, female=21%; Level of injury: Cervical=59.4%, other=40.6% No RHSCIR (n=403): median age=56 (IQR: 30); Gender: male=73.2%, female=26.8%; Level of injury: Cervical=64.9%, other=35.1% Non-RHSCIR (n=58): median age=56 (IQR: 30); Gender: male=75.9%, female=24.1%; Level of injury: Cervical=78.8%, other=21.2% **Treatment:** Patient trajectory was analyzed after being discharged from a specialized acute SCI facility. 3 groups were formed: RHSCIR group received rehab at a specialized facility, No RHSCIR did not receive rehab at a specialized facility, and non-RHSCIR did not attend a specialized facility. Authors then matched 159 RHSCIR and No RHSCIR participants and compared their discharge destination afterward. **Outcome Measures:** Predictors of returning home after attending a specialized (RHSCIR) rehab centre, difference in returning home between receiving rehabilitation at RHSCIR or no rehab. **Chronicity:** Post-acute	1. Receiving rehabilitation, age, and AIS D at admission, and acute LOS were significant predictors of being discharged home after attending RHSCIR ($p<0.05$) 2. In the matched sample of n=159, there was a significant difference in discharge destination (home or other) between RHSCIR rehab or no RHSCIR rehab ($p=0.0004$) with RHSCIR rehab having an increased likelihood to discharge home.
Smith (2002) UK Observational N=800	**Population:** Patients that received rehabilitation within the UK National Health Service. **Treatment:** Spinal cord injured patients who received rehabilitation from either a	1. 13.6% of patients did not use the SIU system. 2. SIU group had significantly lower: • Superficial pressure sores ($p=0.048$).

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
	specialized spinal injury units (SIU) or non-specialized spinal injury units completed a postal self-report questionnaire. **Outcome Measures:** Functional outcome, satisfaction, social activity.	• Need for assistance in grooming (p=0.004), eating (p=0.001), and drinking (p<0.001) in patients with complete tetraplegia. 3. Patients in SIU group were significantly more satisfied with the amount of assistance received (p=0.017). 4. SIU group was more likely to have: • A partner (p=0.012). • Paid employment (p=0.017). • Voluntary employment (p=0.025). • Satisfaction with sex in those with either tetraplegia (p=0.006) or paraplegia (p=0.05). 5. No significant difference was seen in general life satisfaction between the two groups.
Tator et al. (1995) Canada Case Control $N_{Initial}$=552; N_{Final}=552	**Population:** Traumatic SCI; 201/220 consecutive admissions to a newly established specialized interdisciplinary acute SCI unit versus 351 admissions to one of two general hospital trauma units; tetraplegia, paraplegia; incomplete, complete; Male/female ~ 4/1; Median age - 27yr (SCI Specialist unit), 32.0 years (general hospital). **Treatment:** Comparison of those treated in a SCI specialist spinal unit (1973-1981) versus a general hospital trauma unit (1947-1973). **Outcome Measures:** LOS, Mortality rate, Cord Injury Neurological Recovery Index. All collected at 6mo (complete) or 12mo (incomplete).	1. Subjects who were admitted to the specialized SCI unit had significantly shorter acute care LOS than those admitted to the general units (p<0.001). Within the specialized unit subsample, an increased delay from accident to admission resulted in longer LOS (p=0.032). 2. Subjects who were admitted to the specialized SCI unit had significantly reduced mortality than those admitted to the general units (p=0.022). This was especially evident in those with complete SCI. 3. Subjects who were admitted to the specialized SCI unit had significantly greater neurologic recovery (p<0.001).
Heinemann et al. (1989) USA Case Control $N_{Initial}$=338; N_{Final}=338	**Population:** 338 SCI admitted to Rehabilitation, paraplegia, tetraplegia, complete, incomplete. **Treatment**: N=185 initially treated in a specialized short-term acute care unit; Control: N=153 initially treated in general hospitals. **Outcome Measures:** MBI, MRSCICS Patient Functional Level Scheme, Rehabilitation LOS, Efficiency of Rehabilitation Gains (MBI / natural logarithm of LOS)	1. Those receiving specialized care made functional gains with significantly greater efficiency and were transferred to rehabilitation significantly faster (p<0.001). 2. A significantly greater number of people were transferred from general centres with spine instability than from specialized SCI centres (p=0.02). 3. There was no difference between specialized and general acute care with respect to functional status at rehabilitation admission or discharge nor on rehabilitation LOS.

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
Yarkony et al. (1985) USA Case Control $N_{Initial}$=181 N_{Final}=181	**Population:** Traumatic SCI admitted to a specialized rehabilitation unit; Males (n=149) and females (n=32); Avg age 28 years; Tetraplegia (54%), paraplegia (46%); incomplete (58%), complete (42%). **Treatment:** Comparison of those treated acutely in a specialized interdisciplinary spinal unit (n=90) versus a general hospital unit (n=91). **Outcome Measures:** Joint motion, time to rehabilitation admission, all collected at admission to rehabilitation.	1. Those admitted from the specialized SCI unit had significantly improved joint motions (i.e., reduced contractures). More had normal range of motion (p<0.05) and fewer abnormalities. 2. Those admitted from the specialized SCI unit were admitted significantly earlier for rehabilitation as compared to those admitted from the general hospital unit (p<0.01). Those admitted earlier to rehabilitation had reduced numbers of contractures (p<0.01). 3. Those with tetraplegia had an increased incidence of contractures (p<0.01).
Donovan et al. (1984) USA Case Control $N_{Initial}$=1,672 N_{Final}=1,672	**Population:** Traumatic SCI, admitted to a specialized, integrated rehabilitation unit in Australia (n=66) versus those admitted to the United States Model Systems (n=1606); tetraplegia, paraplegia; incomplete, complete. **Treatment:** Those treated in an integrated, specialized interdisciplinary spinal unit (Australia) admitted <48 hours post-injury versus those admitted to the United States Model Systems at 1-15, 16-30, 31-45 or 46-60 days post-injury (reflecting progressively less specialized care). **Outcome Measures:** Incidence of 7 complications collected at 1-15, 16-30, 31-45 or 46-60 days post-injury.	1. Subjects who were cared for in the integrated, specialized unit (Australia) encountered the fewest complications (no statistical analysis was performed). 2. People sustained progressively more complications with longer periods of delayed admission (US Model Systems). Individuals admitted at these longer delays were cared for initially in general hospital units.

Discussion

Most studies examining the effect of specialist versus general SCI care settings focused on the acute period of care only, with the primary outcome measures being taken at admission to rehabilitation and no follow-up after this point. Of the studies reviewed, two investigated the results associated with a specialized, integrated unit comprised of both acute and rehabilitation services (Donovan et al., 1984; Smith, 2002). Donovan et al. (1984) noted rates of six of seven different medical secondary complications typically encountered by individuals with SCI were lowest for the cohort admitted initially (i.e., typically within 48 hours post-injury) to the specialist SCI centre. This cohort was analyzed retrospectively with complication rates determined at various times throughout rehabilitation (i.e., 1-15, 16-30, 31-45, and 46-60 days) and compared to those admitted to specialist SCI centres from more general care settings at similar time periods. Most striking was the absence of decubitus ulcers during any time period for those under more specialized care compared to a progressively increasing incidence for those patients who spent greater time in general care. No statistical analysis was conducted for this study. Smith (2002) conducted a postal survey (i.e., cross-sectional, self-reported survey) of 800 persons who had received care through either a specialist spinal injury unit (n=701) or in a general setting (n=99) within the UK. This cross-sectional sample reported significantly improved outcomes for 10 of 18 health outcomes, 16 of 18 functional outcomes and 5 of 10 social outcomes for those who had received care from the specialist versus non-specialist setting. Notable findings included reduced pressure sores (p=0.048), and a lower level of required assistance for the group who had received specialist care, and there was a trend but no statistically significant difference noted between the groups for life satisfaction (p=0.07).

The remaining studies compared specialized SCI care to general care and were retrospective in nature. Three studies (A. W. Heinemann et al., 1989; Tator et al., 1995; Yarkony et al., 1985) evaluated the impact of specialized acute care SCI units on patient outcomes. Yarkony et al. (1985) compared joint contracture and time to rehabilitation admission outcomes for patients with SCI treated in a specialized acute care SCI unit to those with SCI treated in a general acute care unit. Heinemann et al. (1989) found that a specialized acute care unit reduced acute care LOS, and promoted earlier transfer to rehabilitation. Tator et al. (1995) evaluated the seven-year experience of a newly developed acute SCI care unit and compared outcomes to historical data from pre-existing general trauma units (Tator et al., 1995). In all three studies, patients were transferred significantly faster to comprehensive inpatient rehabilitation from more specialized acute care settings than from general hospital settings, resulting in a reduced LOS in acute care. The two remaining studies compared subjects who received comprehensive, specialized SCI rehabilitation to those who received general rehabilitation (Cheng et al., 2017; McKechnie et al., 2019). Cheng et al. (2017) evaluated the discharge destination for patients with SCI admitted to specialized SCI rehabilitation compared to general rehabilitation in a multi-centreed retrospective cohort study of nine Canadian rehabilitation centres and found significantly higher rates of discharge home to independent living for patients who received specialized SCI rehabilitation. McKechnie et al. (2019) compared outcomes for patients with SCI and brain injury in specialized and non-specialized rehabilitation units over 10 years retrospectively; most patients with SCI received care in non-specialized units. Patients with SCI who received care in specialized SCI rehabilitation had greater levels of impairment on admission (lower FIM scores, higher burden of care) and achieved greater functional outcomes (absolute functional gains) but had a near-double length of stay in rehabilitation.

In general, studies of specialized acute care demonstrated improved medical outcomes associated with more specialized care. In addition to the reduced complication rates noted above by Donovan et al. (1984) and Smith (2002), others have noted that more specialized acute care resulted in less spine instability (A. W. Heinemann et al., 1989) and significantly improved joint motion with reduced incidence of contractures (Yarkony et al., 1985) upon admission to a comprehensive rehabilitation program. Chang et al. (2020) found that specialized rehabilitation significantly improved basic life skills, motor scores and social life. In addition, reduced mortality and improved neurological recovery (as demonstrated by higher scores on the Cord Injury Neurological Recovery Index) were seen in the newly developed specialist SCI unit as compared to the data from pre-existing general trauma units (Tator et al., 1995). It should be noted that a gradual reduction of mortality was seen over the entire study period and that reductions attributed to the specialist unit might also be due to many general gradual improvements in medical care, especially as a historical control was used as the primary basis for comparison.

Only two studies examined the functional benefits realized during rehabilitation associated with SCI-specific acute care. Heinemann et al. (1989) used the MBI to show that those individuals receiving specialist care made functional gains during subsequent rehabilitation with significantly greater efficiency (i.e., functional change/LOS) than those referred from general settings. No statistically significant differences were seen between the specialist versus general groups for either admission or discharge functional levels, nor were significant differences seen with LOS. However, there was a significant reduction in the time from injury to rehabilitation admission for those receiving care in the specialist SCI unit. This implies an overall reduced length of total hospitalization for this group, although this data was not reported. In comparison, Pattanakuhar et al. (2019) found that patients discharged from specialized rehabilitation facilities demonstrated greater improvement on the Spinal Cord Independence Measure. As well, rehabilitation conducted at a specialized facility was an independent predictive factor of SCIM improvement at discharge. Functional benefits associated with early admission and reduced LOS will be reviewed in the next section.

Two studies evaluated SCI-specific rehabilitation care and identified several beneficial patient outcomes. Cheng et al. (2017) found that patients who received SCI-specific rehabilitation care were much more likely to be discharged home than those who received general rehabilitation: for every 100 patients who received specialized rehabilitation care, 11 more were able to return home (rather than nursing or other non-home destinations) compared to general rehabilitation. Similarly, McKechnie et al. (2019) reported significant functional gains for patients who received specialized SCI rehabilitation care compared to those who did not, but these patients also had a longer rehabilitation LOS.

A primary limitation of all studies reported here was the use of retrospective data collection methods and in the case of Tator et al. (1995), the use of historical controls. Another important limitation of some of these studies is the failure to control for (or at least adequately describe) the time to admission to initial care following injury, especially with respect to control subjects (e.g., (Donovan et al., 1984; A. W. Heinemann et al., 1989; McKechnie et al., 2019; Tator et al., 1995; Yarkony et al., 1985). This is an important confounding variable as early admission to a specialized system of care is likely associated with better outcomes as demonstrated in the following section. Therefore, the present conclusions are limited to level 3 evidence and some findings have been reduced to level 4, if not corroborated by or had inadequate controls. While more carefully controlled prospective studies would be difficult to implement, they would be required to strengthen the evidence in this area.

Conclusions

There is level 3 evidence (from three case control studies; (A. W. Heinemann et al., 1989; Tator et al., 1995; Yarkony et al., 1985) that individuals cared for in interdisciplinary, specialist SCI acute care units soon after injury (most being admitted within 48 hours) begin their rehabilitation program earlier.

There is level 3 evidence (from one case control; (Donovan et al., 1984) and level 5 evidence (from one observational study; (Smith, 2002) that individuals cared for in interdisciplinary, specialist acute care SCI units have fewer complications upon entering and during their rehabilitation programs.

There is level 2 evidence (from two cohort studies; (McKechnie et al., 2019; Pattanakuhar et al., 2019)), level 3 evidence (from (A. W. Heinemann et al., 1989)) and level 4 evidence (from one pre-post test; (Chang et al., 2020) that individuals cared for in interdisciplinary, specialist SCI units make more efficient functional gains during rehabilitation (i.e., more or faster improvement).

There is level 3 evidence (from one case control study; (Tator et al., 1995) that individuals cared for in interdisciplinary, specialist SCI units have reduced mortality.

There is level 2 evidence (from one cohort study; (Cheng et al., 2017) that individuals who receive inpatient rehabilitation in specialist SCI rehabilitation units are more likely to be discharged home than those who do not.

> More specialized, interdisciplinary acute SCI care is associated with faster transfers to rehabilitation and may result in fewer medical secondary complications, more efficient functional gains and reductions in overall mortality.

7.0 Early versus Delayed Admission to Specialized SCI Units

As noted by others and in the previous section, earlier as opposed to delayed admission to interdisciplinary, specialized SCI units has been associated with a variety of beneficial outcomes (M. J. DeVivo et al., 1990). The question of whether earlier admission to an organized system leads to enhanced outcomes is inexorably linked to the question of specialist versus general care for individuals with SCI. In all studies in this and the preceding section the authors framed their studies as addressing either the question of delay or the question of interdisciplinary, specialist care yet similar designs were employed for each (i.e., retrospective case control). For those subjects experiencing a delay to admission to a specialized SCI unit, it was either presumed or established that preceding acute care was conducted at a general hospital unit. The author simply chose to characterize this as either a delay or more general care. For the present review we have maintained this distinction as originally intended by each author, especially, as in some cases, there is little or no verification of the general nature of the pre-admission care or the time of first admission, respectively. However, the reader is advised that the specific findings and conclusions reached in both sections are most likely associated with a delay to an interdisciplinary, specialized acute or rehabilitation SCI unit with prior care delivered at a general hospital facility.

In addition, much variation exists in the literature that addresses the question of delayed admission. There is no uniform or accepted definition of what constitutes a delay, and this varies depending on the context of the study, most notably whether it is conducted from an acute versus rehabilitation perspective. For the present review, all studies which examine this question by comparing two or more groups within the first week post-injury have been examined separately from those with an initial time period greater than 1 week post injury. These have been termed 1) Acute and 2) Post-acute studies, respectively.

Table 12. Effect of Early versus Delayed Admission (Acute Studies) on Rehabilitation Outcomes

Author Year **Country** **Research Design** **PEDro Score** **Total Sample Size**	**Methods**	**Outcome**
Dalyan et al. (1998) USA Case Control $N_{Initial}$=482; N_{Final}=482	**Population:** 482 men and women with traumatic SCI admitted to a United States Model Systems SCI Centre with specialized SCI acute care and rehabilitation services. Subjects included those with tetraplegia (256)	1. Subjects who were admitted earlier (<24 hours) had significantly fewer contractures than those admitted later (>24 hours – 60 days) (p=0.05). 2. Other factors associated with an increased incidence of contractures

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
	& paraplegia (226) and AIS A, B, C (362) & D (120). **Treatment:** No intervention. Comparison of those admitted to a specialized spinal acute care and rehabilitation unit <24 hours post injury versus >24 hours-60 days post-injury **Outcome Measures:** Incidence of contractures during initial post-traumatic hospitalization.	included tetraplegia versus paraplegia (p<0.01), presence of a pressure ulcer (p=0.05), co-existence of head injury (p<0.05).
De Vivo et al. 1990 USA Case Control $N_{Initial}$=661; N_{Final}=661	**Population:** 661 people with SCI admitted to a United States Model Care System Centre with specialized SCI rehabilitation services. Subjects included those with tetraplegia and paraplegia and also those with incomplete versus complete injuries but frequencies were not provided. Average ages for early versus delayed admission groups were 29.5 and 32.0 years old respectively. **Treatment:** No tx per se, comparison of those admitted earlier (<24 hours post injury) versus later (>24 hours) to a specialized integrated spinal unit (i.e., combined acute care and rehabilitation). Subjects were sub-grouped into i) paraplegia, incomplete, ii) paraplegia, complete, iii) tetraplegia, incomplete, iv) tetraplegia, complete. **Outcome Measures:** LOS, Hospital charges, Incidence of medical complications, Neurologic recovery, Mortality all collected at Discharge.	1. Those with complete paraplegia (p=0.0169) & incomplete tetraplegia (p=0.0001) admitted earlier (<24 hours) had significantly shorter total hospitalization LOS. A similar trend for those with incomplete paraplegia (p=0.0568), no difference for those with complete tetraplegia (p=0.928). 2. Mean hospital charges were less for subjects with complete (p=0.0099) and incomplete (p=0.0134) tetraplegia who were admitted earlier. Similar trend for those with incomplete paraplegia (p=0.0607), no difference for complete paraplegia (p=0.4777). 3. In general, no overall differences were seen in the development of medical complications between the early versus late admission groups. A few differences for incidence specific complications. 4. Trend for increased neurologic recovery with early admission in that 10/315 (3.2%) versus 4/401 (1.0%) in early versus late groups had complete recovery (p=0.08). Author warns of bias in this finding. 5. Mortality comparisons not possible within sample for early versus late admission groups. Comparison with historical data suggests enhanced survival rates with early admission.

Table 13. Effect of Early versus Delayed Admission (Post-Acute Studies) on Rehabilitation Outcomes

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
Scivoletto et al. (2006) Italy Case Series	**Population:** Mean age=55.1yr; Gender: males=71, females=46; Level of injury: C=37, T=59, LS=21; Severity of injury: AIS A=36,	1. Delayed admission still resulted in significant improvement in:

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
N=117	C=53, D=28; Etiology of injury: non-traumatic=81, traumatic=36 **Treatment:** Charts of patients admitted to rehabilitation 90 days or more post injury (mean 136±55.6 days) were examined. All patients received individual PT 40 minutes twice a day, 5 days a week and one 60 min therapy on Saturday. Patients also received water therapy 45 mins twice weekly and OT 45 min 3day/week. **Outcome Measures:** BI, Walking Index for Spinal Cord Injury (WISCI), Rivermead Mobility index (RMI), bladder management, discharge destination, AIS. All collected at admission and discharge.	2. BI, WISCI, RMI, Motor scores, gait ($p<0.001$). 3. Mean LOS was 99.7±62.5 days (median 100 days). 4. At discharge 49 of 117 patients were able to achieve normal bladder control, 28 used clean intermittent catherization and 34 self intermittent catherization. 5. 90% (104) patients returned home post rehabilitation, 8% were transferred to acute ward due to complications, and 2% were discharged to other rehabilitation facilities. 6. No significant neurological recovery was seen in the AIS A group; however, 51% of those in the AIS C group improved to AIS D ($p=0.007$).
Amin et al.(2005) England Case Control $N_{Initial}$=432; N_{Final}=432	**Population:** SCI, tetraplegia, paraplegia, traumatic. **Treatment:** No intervention. Comparison of those admitted to a specialized integrated spinal unit (i.e., combined acute and rehabilitation) with or without a delay between injury and referral (>3 days) and between referral and admission (>7 days). **Outcome Measures:** LOS.	1. Those admitted with a delay (>7 days) following referral had significantly longer LOS ($p<0.001$). This was for people with both complete (N=59) and incomplete (N=29) injuries but not for those without spinal cord damage (N=24). 2. More severe injuries (as determined by Injury Severity Scores) were more likely to have longer LOS (Spearman's =0.593, $p<0.0001$). 3. Those who were admitted with a delay between injury and referral (>3 days) did not differ on LOS with those who did not experience a delay ($p=0.44$). 4. The primary reasons for delays between referral and admission for those with complete injuries were I) achieving medical stability and ii) absence of beds. For those with incomplete injuries the same primary reasons were identified but in reverse order.
Scivoletto et al. (2005) Italy Case Control $N_{Initial}$=150; N_{Final}=150	**Population:** SCI, tetraplegia, paraplegia, complete, incomplete, traumatic. **Treatment:** No intervention. Comparison of those admitted to a specialized Spinal Rehabilitation unit at one of 3 time periods following injury (<30 days, 31-60 days, >60 days). **Outcome Measures:** LOS, AIS motor scores and impairment grade, BI, Rivermead Motor Index (RMI), Walking Index for SCI (WISCI),	1. Those admitted earliest (<30 days) had significantly better BI at discharge than those with longer delays (>60 days) ($p=0.006$). They also demonstrated significantly greater changes ($p=0.003$) and greater efficiency ($p<0.001$) on the BI. 2. Those admitted the earliest (<30 days) had significantly better mobility (i.e., RMI) at discharge than those with longer delays (>60 days)

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
	Efficiency measures for all were calculated by dividing by LOS.	(p=0.03). They also demonstrated significantly greater changes (p=0.001) and greater efficiency (p=0.04) for the RMI. 3. There were no significant differences between the early versus later admissions with respect to walking (WISCI) or ASIA motor scores (p=0.63 or p=0.81). 4. Those admitted earliest had the shortest LOS; these differences were not significant (p=0.15).
Sumida et al. (2001) Japan Case Control $N_{Initial}$=139; N_{Final} =123	**Population:** 123 people with SCI admitted to a Japanese Hospital System with specialized SCI rehabilitation services following acute care. Subjects included those with tetraplegia and paraplegia (frequencies not provided) with AIS A (51), B (8), C (35) and D (29). **Treatment:** No intervention. Comparison of those admitted earlier (<2 weeks post injury) versus later (>2 weeks) to a specialized spinal rehabilitation unit. Subjects were sub-grouped into i) tetraplegia, ii) paraplegia, iii) central cord. **Outcome Measures:** LOS, FIM, FIM motor score, FIM gain, FIM efficiency all collected at Discharge.	1. Subjects who were admitted earlier (<2 weeks) had significantly shorter LOS than those admitted later (p<0.0005). 2. FIM gain (p<0.0001) and FIM efficiency (p<0.0001) were significantly greater for subjects admitted earlier versus later. Note: the early admission subjects had lower initial motor and total FIM scores than did the delayed admission group (p<0.05). 3. Correlations between ASIA motor and FIM scores in various subgroups and at admission and discharge yielded a variety of associations ranging from very weak to strong correlations (r=0.03-0.92) with the majority of these correlations significant (p<0.05).
Aung & El Masry (1997) UK (Wales) Case Control $N_{Initial}$=219; N_{Final}=219	**Population:** 173 men (mean age 35.5) and 46 women (mean age 44.2) with traumatic SCI admitted to a Spinal Injuries Centre with specialized SCI acute care and rehabilitation services. Subjects included those with tetraplegia (116) and paraplegia (103). **Treatment:** No intervention. Comparison of those admitted 1. (<1 week post injury) versus 2. (<2 month) versus 3. (>2 months) to a specialized spinal acute care and rehabilitation unit. **Outcome Measures:** LOS, incidence of secondary complications all collected at discharge (i.e., during initial post-traumatic hospitalization).	1. Subjects with paraplegia who were admitted earlier (<1 week and <2 months) had significantly shorter LOS than those admitted later (p<0.05). 2. Subjects with tetraplegia who were admitted earlier (<1 week) had significantly shorter LOS than those admitted later (>2 months) (p<0.05). 3. The incidence of most secondary conditions did not differ between early versus later admissions for those with paraplegia or tetraplegia. However, those with paraplegia or tetraplegia did have lower incidence of pressure sores with earlier admission (<1 week) (p<0.001).
Oakes et al. (1990) USA Case Control $N_{Initial}$=197; N_{Final}=197	**Population:** 197 people with traumatic SCI admitted within 1 year of injury to a Level 1 trauma Centre with specialized SCI rehabilitation services. Male / female (158 / 39); Tetraplegia / paraplegia (102 / 95);	1. Those admitted earlier had significantly shorter total hospitalization LOS (p<0.01). 2. Those admitted earlier with tetraplegia had fewer medical

Author Year Country Research Design PEDro Score Total Sample Size	Methods	Outcome
	Average ages for groups were 27.2 –32 years old. **Treatment:** No intervention. Comparison of those admitted earlier (<median) versus later (>median) to a specialized integrated spinal unit (i.e., combined acute care and rehabilitation). Subjects were grouped by tetra versus para and by early versus late admission by median admission values of 11 (tetraplegia) versus 21 (paraplegia) days. **Outcome Measures:** LOS, incidence of medical complications, incidence of surgical intervention.	complications and less frequent spinal surgery versus those admitted later (no group analysis performed). Those admitted earlier with paraplegia had no difference in medical complications and more frequent spinal surgery. 3. Similar reductions in total hospitalization LOS with earlier admissions for both those with tetraplegia (p<0.01) and paraplegia (p<0.05) in a re-analysis of the sample with groupings based on admissions <24 hours versus >24 hours post-injury.

Discussion

The present section describes a series of studies in which investigators examined the effect of delayed admission to a specialist SCI unit. However, there is not a common definition of what constitutes a "delayed" admission. Therefore, to assist the reader in summarizing these delays, the details of the various time frames under examination are outlined along with their respective results in Table 14.

Table 14. Studies Examining Delayed Admission to SCI Unit (Comparison Studies Only)

Study	Experimental Groups (time post-injury)	Outcome Measure	Result
Amin et al. (2005)	• <=3 days • >3 days or • <=7 days from referral* • >7 days from referral	LOS LOS	- +
Scivoletto et al. (2005)	• <=30 days* • 30-59 days • >60 days	LOS Functional Status Neurological Status	~ + -
Sumida et al. (2001)	• <=2 weeks* • >2 weeks	LOS Functional Status Neurological Status	+ + +
Dalyan et al. (1998)	• <=24 hours* • >24 hours	Secondary complications (contractures)	+
Aung & El Masry (1997)	• <=1 week* • <2 months	LOS Secondary complications	+ -
DeVivo et al. (1990)	• <=24 hours* • >24 hours	LOS Secondary complications Neurological Status	+ - ~

Study	Experimental Groups (time post-injury)	Outcome Measure	Result
Oakes et al. (1990)	• <=11 days (for tetraplegia)* • >11 days or • <=21 days (for paraplegia)* • >21 days	LOS Secondary complications	+ + (tetraplegia only)

Two acute studies were reviewed which each employed retrospective, two-group (case control) designs with a definition of 24 hours as to what constituted an "early" versus "delayed" admission (Dalyan et al., 1998; M. J. DeVivo et al., 1990). Each study examined a fairly large cohort admitted to a multidisciplinary, specialized SCI unit (i.e., United States model system centre) within 24 hours post-injury versus those admitted after 24 hours. Neither study reported the actual injury to admission times for the "delayed" admission group and both failed to provide information about the referral sources (e.g., specialist versus general nature). DeVivo et al. (1990) noted that total hospital LOS (i.e., acute and rehabilitation) was reduced for all patient groups except for those with complete tetraplegia when admission was not delayed. Mean hospital charges were also reduced for early admission subjects except those with complete paraplegia and there were some reductions in the incidence of specific medical complications with early admission for some patient groups, most notably a trend for a reduction in pressure sores for all but those with incomplete paraplegia. In addition, these authors also reported a trend for increased neurologic recovery and reduced mortality with earlier admission, although they also noted methodological concerns associated with the actual measures employed. In a study focusing on the development of contractures, Dalyan et al. (1998) noted a reduced incidence of contractures for those admitted to a specialized unit within 24 hours.

Of the studies examining time periods longer than one week (i.e., post-acute), five studies have been reviewed (Amin et al., 2005; Aung & el Masry, 1997; Oakes et al., 1990; G. Scivoletto et al., 2005; Sumida et al., 2001). The initial admission delays examined ranged from 1 week (Aung & el Masry, 1997) to 1 month (G. Scivoletto et al., 2005). All studies employed retrospective case control designs and all examined LOS for the entire period of initial hospitalization as a primary outcome measure. In all cases, those admitted earlier had reduced LOS, regardless of the considerable variation between studies in the definition of what constituted a delay in admission. It should be noted that this difference in LOS was statistically significant for all studies but one (G. Scivoletto et al., 2005), for which they had the longest delay of 1 month.

Functional benefits were also demonstrated for individuals admitted earlier. Scivoletto et al. (2005) reported that those admitted earlier than 1 month had significantly greater gains and greater efficiency associated with the BI as well as greater mobility gains and efficiency as measured by the Rivermead Mobility Index (RMI) but there was no difference with respect to walking as measured by the Walking Index for SCI (WISCI). Similarly, Sumida et al. (2001) reported increased FIM gains and efficiencies for those admitted earlier than 2 weeks post-injury as compared to those admitted later. Interestingly, these investigators also showed that for a majority of the various patient groups tested (i.e., paraplegia and tetraplegia, early and late), significant associations were seen between a measure of function (i.e., FIM) and a measure of impairment (i.e., ASIA motor scores). However, Scivoletto et al. (2005) found no effect of early versus late admission on AIS motor scores. A follow-up study conducted by Scivoletto et al. (2006) reported significant improvements in all measures employed in their prior study (i.e., BI, RMI, WISCI, ASIA motor scores) as assessed between admission to discharge even in those subjects that were admitted at ≥90 days post-injury – although there was no control condition reported to confirm that these improvements were different than might have been seen with earlier admission. Taken together, these studies suggest better outcomes are seen with earlier admission, although improvements are still possible even if rehabilitation onset is delayed for several months.

Other investigators examined the role of early versus late admission on the incidence of secondary medical complications. Oakes et al. (1990) reported that earlier admissions were associated with a reduced incidence of secondary medical complications in those with tetraplegia and Aung and el Masry (1997) noted a reduction in the number of pressure sores for all subjects with earlier admission.

Despite the apparent benefits of earlier admission to a multidisciplinary, specialized integrated SCI unit, there are significant issues which serve to constrain the strength of evidence in this area. First and foremost is the retrospective nature of all studies conducted to date. It is difficult to ascertain how comparable the "early" versus "later" groups truly are with respect to potential confounding variables. In particular, there is a paucity of information on the pre-admission level of care and medical status, especially for the delayed admission groups. In addition, it is difficult to discern the potential role that medical status or the presence of secondary medical complications may have played in admission delays. The retrospective nature of the studies outlined in this and the previous section makes it difficult to determine if individuals prone to complications and with poorer medical status would have naturally comprised a greater proportion of the delayed admission groups. Therefore, as noted earlier, more carefully controlled prospective studies would be required to strengthen the evidence in this area.

Conclusions

There is level 3 evidence (based on several retrospective, case-control studies) that individuals admitted earlier to interdisciplinary, integrated specialist SCI units have a shorter total hospitalization length of stay than those admitted later.

There is level 3 evidence (based on several retrospective, case-control studies) that individuals admitted earlier to interdisciplinary, integrated specialist SCI units make greater functional gains in a shorter period of time (i.e., greater efficiency) than those admitted later.

There is level 3 evidence (based on several retrospective, case-control studies) that individuals admitted earlier to interdisciplinary, integrated specialist SCI units have fewer secondary medical complications (especially pressure sores) than those admitted later.

There is level 4 evidence (based on case series studies) for positive utility of admission to rehabilitation even at delays ≥90 days post injury.

Because of the variability between studies as to what constitutes "early" admission to interdisciplinary, specialist integrated SCI units, it is not possible to determine a specific period for optimal admission. At least one study has demonstrated benefits with an early admission described as ≤30 days post-injury. The majority of studies defined early admissions as 1-2 weeks post-injury, while studies focused on acute care describe early admission as within 24 hours post-injury.

Earlier admission to specialized, interdisciplinary SCI care is associated with reduced length of total hospital stay and greater and faster rehabilitation gains with fewer medical secondary complications.

Prospective studies with stronger designs are needed to strengthen the evidence and provide more direction as to the optimal model of care.

8.0 Health Care After SCI Inpatient Rehabilitation

8.1 Outpatient and Follow-up Care

Various authors have noted the importance of providing continued, regular, specialized follow-up care following discharge from rehabilitation (Cox, Amsters, & Pershouse, 2001; Dryden et al., 2004; Ernst JL, 1998). In a recent review, (Bloemen-Vrencken, de Witte, & Post, 2005) described various follow-up programmes for persons with SCI. These authors noted that the vast majority of the papers in this area offered little more than a description of the program with five of these being identified as either experimental or quasi-experimental in nature. Of these, two studies examined the effect of various models of care associated with routine after-care (Dinsdale, Thurber, Hough, & Rencz, 1981; Dunn, Love, & Ravesloot, 2000), while the remaining 3 studies focused on evaluations of telehealth applications (specifically telemedicine) or nursing education for the prevention of pressure sores or UTIs (Barber, Woodard, Rogers, & Able, 1999; Phillips, Temkin, Vesmarovich, Burns, & Idleman, 1999; Phillips, Vesmarovich, Hauber, Wiggers, & Egner, 2001). The present section describes the literature examining different approaches to the provision of follow-up care, recognizing that several of these involve the investigation of the role of telehealth applications.

Trezzini et al. (2019) performed a needs assessment of 490 community-dwelling individuals with SCI using a custom survey. They found a perceived high need for improved healthcare, equipment and technical aids, as well as specialist, multidisciplinary SCI care. While the least fulfilled needs for services were peer support, support for family caregivers and psychological counselling. This is similar to the results found by Cox et al. (Cox et al., 2001), who performed a needs assessment of 54 community-dwelling individuals with SCI using structured telephone interviews. Some of the issues identified as the greatest areas of need included dealing with physical changes, transportation, work issues, ongoing education and pain management. The primary barriers to needs being met were overwhelmingly related to limitations of local expert knowledge but also included inadequate funding, complicated processes or service fragmentation and not knowing where to go for help. Preferred service delivery options in order of preference included telephone advice, home visits, SCI outpatient clinics, community-based service and regional hospital clinics (Cox et al., 2001). Similar suggestions have been provided by clinicians, especially as they observe the consequences of inadequate care received by some individuals upon discharge from inpatient rehabilitation programmes (Vaidyanathan et al., 2004). Despite these reports, little direct evidence has been established for the effectiveness of different methods of providing follow-up care.

Table 15. Outpatient and Follow-up Care

Author, Year Country Research Design	Methods	Outcomes

PEDro Score Sample Size		
Dallolio et al. 2008 Italy RCT PEDro score=6 $N_{initial}$=137, N_{final}=127	**Population:** Those discharged from initial rehabilitation care; Mean age=40yr; Gender: males=107, females=20; Level of injury: tetraplegia=47, paraplegia=77, unknown=3; Median rehab stay=186.5-230 days. **Intervention:** Usual follow-up care versus the same combined with 8 weekly telemedicine sessions followed by nine bimonthly telemedicine sessions. Telemedicine sessions consisted of patient interviews to assess signs / symptoms of various complications & associated recommendations. Alternatively, sessions focused on functional issues. **Outcome Measures:** FIM, SCIM II, healthcare utilization, status of various complications and satisfaction with care collected just before discharge and 6 months post.	1. There was no difference in FIM or SCIM II scores across all 3 sites, however, there was a significant increase in FIM gain at the largest (Italian) site for both overall FIM and FIM motor score (p<0.01) as well as some individual SCIM II items. 2. There was no difference between groups in prevalence of secondary complications. 3. Persons receiving the telemedicine contacts were significantly more satisfied with their care than those receiving routine follow-up care (p<0.001).
Bloeman-Vrencken et al. 2007 Netherlands Prospective Controlled Trial $N_{initial}$=149, N_{final}=62	**Population:** Those receiving initial rehabilitation care; Mean age=37.8yr (transmural), 36.1yr (usual care); Gender: males=48, females=14; Level of injury: tetraplegia, paraplegia; Severity of injury: Complete, incomplete; Avg rehab stay=270.7 (transmural), 294.1 (usual care) d. **Intervention:** Matched sample of those receiving transmural care (community patients served by transmural nurse liaising with other health professionals) versus 'usual follow-up care' (periodic visits to rehabilitation doctor / centre). **Outcome Measures:** Prevalence of pressures sores, UTIs or other complications and number and duration of associated hospital re-admissions assessed over first year post-discharge.	1. No difference between groups in prevalence of pressure sores and UTIs or other complications. 2. No difference between groups in hospital re-admissions due to secondary complications.
Dunn et al. 2000 USA Prospective Controlled Trial $N_{initial}$=371, N_{final}=371	**Population:** *SCI-specialist follow-up care (n=235):* mean age=56.6yr; Gender: male=99%, female=1%; Level of injury: paraplegic=52%, tetraplegic=48%; Severity of injury: complete=46%, incomplete=54%; Time since injury=19.4 yr. *No follow-up care (n=136):* mean age=47.9yr; Gender: male=66%, female=44%; Level of injury: paraplegic=58%, tetraplegic=42%; Severity of injury: complete=62%, incomplete=38%; Time since injury=18.2 yr. **Intervention:** Follow-up care (routine check-ups in SCI Outpatient Clinic) versus no follow-up care (presumably problem-based primary care).	1. Those receiving regular follow-up scored higher on all 3 subscales of CYH, Health (p=0.0068), Independence (p=0.005) and Absence of Depression (p<0.0001). 2. Those receiving regular follow-up reported similar secondary conditions as those without routine follow-up but with reduced frequency and rated it as less severe.

	Outcome Measures: Secondary Condition Surveillance Instrument (SCSI), Check Your Health (CYH) Questionnaire. One time survey of both groups.	
Phillips et al. 1999 USA Prospective Controlled Trial $N_{initial}$=35, N_{final}=35	**Population:** *Telephone group (n=13):* mean age=29.6±6.4; Gender: male=69%, female=31%; Level of injury: not reported; Severity of injury; not reported; Time since injury: not reported. *Video group (n=12):* mean age=33.4±13.8; Gender: male=69%, female=31%; Level of injury: not reported; Severity of injury: not reported; Time since injury: not reported. *Standard care (n=10):* mean age=38.1±15.2; Gender: male=69%, female=31%; Level of injury: not reported; Severity of injury: not reported; Time since injury: not reported. **Intervention:** Subjects were recruited to one of 3 groups: i) Video group: received weekly counselling sessions for 10-12wk using AT&T Picasso Still-Image video unit for the first 6-8wk followed by 4-6wk of weekly telephone counselling sessions; ii) Telephone group: telephone counselling for 10wk; iii) Standard care group. **Outcome measures:** Pressure ulcer incidence; frequency of health care utilization. All groups were surveyed every 2-3mo.	1. Ulcer incidence: video group had highest number of identified/reported pressure ulcers followed by the standard care group then the telephone group although none of these differences were statistically significant (p>0.05). 2. Health care utilization: annualized ER visits, hospitalizations and provider visits were lowest in standard care group and similar for telephone and video groups although none of these differences were statistically significant (p>0.05).
Shem et al. 2017 USA Pre-Post $N_{initial}$=10, N_{final}=8	**Population:** Mean age: 34.4yr; Gender: male=8, female=2, Level of injury: cervical=7, thoracic=3; Severity of injury: AIS A=7, B=1, C=2. **Intervention:** Individuals with SCI participated in a telemedicine program for pain, bladder, skin management, medication changes and lab results using iPads for 6 mo. Outcome measures were assessed at baseline and at 6 mo. **Outcome measures:** Healthcare utilization, Quality of life (QoL), Reintegration to Normal Living Index (RNLI), Life Satisfaction Index A (LSI-A), Patient Health Questionnaire (PHQ-9) and program satisfaction survey.	1. Over the course of 6 mo, 57 in person physician visits were reported. This included visits to gastroenterologists, neurologists, ophthalmologists, orthopedics, otolarnygologists, pain specialists, pulmonary specialists, urologists and wound care specialists. 2. A total of 10 ER visits and 4 hospitalizations occurred. The majority of which were not using telemedicine that month. 3. A total of 16 telemedicine visits occurred via FaceTime, where physicians were successfully able to address topics related to spasticity, skin management, bladder and bowel function, pain, medications, heterotopic ossification and general follow-ups. 4. A total of 9 nurse encounters occurred over the phone or via FaceTime. Nurses were able to address topics related to skin checks, bladder irrigation, bowel training programs and changes in urine. 5. No significant differences in QoL, RNLI, LSI-A or depression (PHQ-9) were observed from baseline to 6 mo.

		6. All users reported positive experiences with the program and said they would like to continue with the program.
Derakhshanrad et al. 2015 Iran Pre-Post $N_{initial}$=134, N_{final}=134	**Population:** Median age: 27yr; Gender: male=104, female=30; Level of injury: C1-4=8, C5=6, C6=8, C7-8=4, T1-6=14, T7-12=91, L1-S1=3; Severity of injury: AISA A=134. **Intervention:** Patients with complete SCI (AIS A) completed an outpatient rehabilitation program consisting of bimonthly education programs, combined with twice-weekly OT, PT, and home nursing for a 6-month period. Outcome measures were assessed at baseline and post-treatment. **Outcome measures:** Spinal Cord Independence Measure (SCIM III) score.	1. A significant increase in median total SCIM III score was observed when baseline scores were compared with post-treatment scores (p<0.001). 2. Increases in SCIM III scores were greater in lower cervical and thoracic cases (8.75 and 13.5). 3. No improvement was observed in self-care (feeding, bathing, dressing and grooming) or mobility (room, toilet, indoors and outdoors) for upper cervical level patients. 4. Subjects with injury below C7 had a significant gain in sphincter management scores (5-8 units). 5. Subjects with L1-S1 injury showed the greatest improvement in mobility (indoors and outdoors) and sphincter management subscales. 6. With the exception of high cervical patients, all subgroups significantly improved their SCIM III score (p<0.05).
Zinman et al. 2014 Canada Pre-Post $N_{initial}$=21, N_{final}=14	**Population:** Mean age: 46.6±10.1yr; Gender: male=10, female=11, Level of injury: paraplegia=4, tetraplegia=9, unknown=1; Severity of injury: complete=2, incomplete=11, unknown=1. **Intervention:** Participants evaluated the effectiveness of a community reintegration outpatient (CROP) service for promoting well-being and community participation following SCI. Outcome measures were assessed at baseline, 12 wk and 3 mo. **Outcome measures:** Mooring Self-Efficacy Scale (MSES), Impact on Participation and Autonomy (IPA), Positive Affect and Negative Affect Scale (PANAS), Coping Inventory of Stressful Situations (CISS), World Health Organization Quality of Life (WHOQOL-BREF), semi-structured qualitative interviews.	1. MSES and PANAS significantly improved from baseline to 12 wk (p<0.05), however, no significant differences were observed at 3 mo. 2. No significant differences were observed in any other outcome measures. 3. Qualitative analysis identified four major themes related to therapeutic benefit: 1) role of self, 2) knowledge acquisition, 3) skill application, and 4) group processes.
Lugo et al. 2007 Columbia Pre-Post $N_{initial}$=208, N_{final}=42	**Population:** Mean age=32.6 yr; Gender: males=33, females=9; Level of injury: C=14, T1-6=14, below T6=14; Severity of injury: AIS A=26, B=4, C=5, D=6, E=1 **Intervention:** Patients received a 2-phase interdisciplinary rehabilitation program consisting of a short in-patient phase (mean=13.5 days) and an out-patient phase over 18mo. **Outcome Measures:** Motor FIM, ASIA motor score, Complications assessed over 5 periods including admission to the end of the first month and then months 2-3, 4-6, 7-12, 13-18.	1. Motor FIM scores progressively increased significantly from admission to first mo and after 1yr of rehabilitation (p<0.01) showing most marked increase between admission and mo 2-3. 2. Patients in AIS A and B groups reached motor FIM ceiling scores in the 18th mo, while those is the C, D, E group reached ceiling in the 12th mo. 3. AIS motor scores progressively increased from admission over 18 mo, however, persons with cervical injuries had most marked increases between admission and mo 2-3. 4. Complication rates for those conditions often associated with SCI (i.e., pressure sores,

		spasticity, pain, incontinence) remained high over the study period (deemed no different that in hospital-based programmes).
Vesmarovich et al. 1999 USA Pre-Post $N_{initial}$=8, N_{final}=8	**Population:** Age range=38-78 yr; Gender: male=8, female=0; Level of injury: cervical=5, thoracic=3; Severity of injury; not reported; Time since injury: not reported. **Intervention:** Weekly telerehabilitation visits using Picasso Still-Image Videophone which simultaneously transmits video and audio over ordinary telephone lines. Participants and family members received 30-minute hands-on training session with equipment. Informal interviews with participants and families conducted to determine satisfaction. **Outcome measures:** Number of clinic visits, status of pressure ulcers, subjective satisfaction assessment completed by patients, families and care providers.	1. Mean of 7 visits /patient (range 1-18) via in-home video consult. 2. Seven of 12 wounds were healed over 8 patients. 3. Telerehabilitation approach was accepted as a valid alternative to clinic visits by patients and family members – for many it was preferred. 4. Clinicians identified several technical concerns throughout project but these were solved.
Kim et al. 2012 Korea Observational $N_{initial}$=93, N_{final}=93	**Population:** *SCI(n=57):* Mean age: not reported; Gender: male=58%, female=42%; Level of injury: not reported; Severity of injury: not reported. *Health Professionals (n=36):* Mean age: not reported; Gender: male=93%, female=7%. **Intervention:** No intervention. Retrospective survey evaluating interest and opinion of telerehabilitation in individuals with SCI and health professionals. **Outcome measures:** Awareness, understanding, value, needs, and desirability of telerehabilitation.	1. Survey responses indicated interest in telerehabilitation services among individuals with SCI, as 46.6% rated telerehabilitation as very positive. 2. There was interest in services that could be used to resolve issues on unmet medical needs of individuals with a disability related to health monitoring, sustaining health, rehabilitation interventions, and independence in activities of daily living. 3. The most required need for service was reported as UTI (21.9%), followed by pressure ulcers, central pain management, orthostatic hypotension, depression, obesity management, paralytic ileus, osteoporosis and pneumonia. 4. Patients reported an internet-connected service as the preferred method of telerehabilitation. 5. Of the physicians surveyed, 69.4% were aware of telemedicine, 86.1% reported they are inexperienced with telemedicine, 47.2% preferred a video system with telemedicine and 38.9% rated the desirability of telemedicine as positive. 6. Telerehabilitation risks were ranked in order of importance by health professionals as: (1) concerns relating to medical responsibility, (2) possibility of medical malpractice, (3) financial burden of initial equipment, (4) health insurance cost, (5) misunderstanding of roles and interests, (6) over issuing electronic prescriptions, (7) lack of telerehabilitation professionals and training programs, (8) technical issues on privacy and security. 7. SCI rehabilitation was the most physically requested area of telerehabilitation services (23.4%).

Discussion

Telerehabilitation Programs

Telehealth applications seem especially amenable to the provision of follow-up care given the typical care model of specialized health care services centralized in large urban centres that must continue to meet the needs of patients as they return to their disparate communities and as they link with primary care practitioners, who often lack specialized knowledge about optimal SCI management. Dallolio et al. (Dallolio et al., 2008) conducted a multi-centre RCT (n=127) across three centres in Italy, Belgium and the UK that employed a series of telemedicine videoconferences that served to assess the risk of secondary complication development in informing prevention and treatment recommendations and also to address issues that would enhance function. Overall, patients that received the telemedicine sessions did not show significant increases in FIM or SCIM II gains, nor reductions in secondary complication development as compared to those who underwent routine follow-up visits. However, site by site analysis demonstrated that patients participating in the telemedicine intervention at the largest site (Italy, n=59 of 127) did show significantly increased functional benefits. In addition, when considering participants across all three sites, patients were generally more satisfied with their care when receiving telemedicine visits as an adjunct to their regular care.

Earlier studies have also suggested that telehealth has promise in delivering education directed towards preventing secondary complications – most notably pertaining to pressure sore management. Vesmarovich et al. (1999) and colleagues published two separate reports noting the potential of a telehealth application (i.e., Picasso Still-Image Videophone) in managing and preventing further pressure sores (Phillips et al., 1999; Vesmarovich et al., 1999). In an exploratory pilot study using a pre-post study design (n=8), Vesmarovich et al. (1999) reported that this approach facilitated education, allowing it to be provided at the point of need, thereby reinforcing previous inpatient rehabilitation education. Phillips et al. (1999) compared the same videophone technology to telephone-only consultation or standard care in a prospective controlled trial (n=37) investigating participants newly discharged from inpatient rehabilitation to home. Standard care consisted of access to a helpline which offered free information and counselling over the study period. The videophone group received weekly counselling sessions focusing on self-checking for pressure ulcers and other related education via videophone for 6-8 weeks followed by weekly telephone counselling for 4-6 weeks. Similar activities were conducted with the telephone group for 10 weeks following discharge. No significant differences were reported across the three groups with respect to doctor/hospital/emergency department visits, calls to helpline, pressure sore occurrences/characteristics or employment status. The videophone group reported the highest number of ulcers over a variable follow-up period of 7±2 months but this was attributed to more stage I and II ulcers being identified using this approach. In addition, participants in the videophone group had the highest rate of return to work. The authors did note that this study was severely limited by inadequate sample size, inability to control for confounding variables and non-randomized design and therefore the level of evidence assigned to this article has been downgraded to Level 4. Power calculations assuming 80% power revealed that a sample size of 120 would have been required to detect an effect of the intervention in increasing post-injury employment by 5%.

More recently, Shem et al.(Shem, Sechrist, Loomis, & Isaac, 2017) examined the effect of video telemedicine with iPads on healthcare utilization and medical management in a pre-post test of individuals with SCI. Individuals were able to connect and discuss a variety of medical issues (e.g., general hospital follow-up, SCI primary care, medications, speciality topics) with a SCI specialist, without needing to travel to a physician’s office. Although statistical comparison of health-care utilization was not conducted, trends in descriptive data suggest that patients who utilized more telemedicine visits reported fewer emergency department visits and hospitalizations. All participants sought care from a physician in-person at some point during the study. Results from the program satisfaction survey were positive, as participants felt comfortable about their privacy, found the iPad easy to use and 100% reported that they would like to continue the program. However, measures relating to quality of life and depression were not statistically significant. Given the small sample size, descriptive and non-conclusive findings of this study, future research is necessary to determine the efficacy of iPad telemedicine.

In an observational study, Kim et al. (2012) conducted a retrospective survey evaluating telerehabilitation needs and opinions in both health professionals and individuals with SCI. From the prescriptive of health professionals, the vast majority were aware of telemedicine and interested in providing it; however, 86.1% reported that they were inexperienced in providing telerehabilitation care. Additionally, the majority of health professionals had concerns relating to medical responsibility and malpractice, as well as the financial burden associated with the initial set up of telerehabilitation services. Despite this, health professionals recognized a need for telerehabilitation services as SCI rehabilitation was the most frequently requested area of telerehabilitation services. From the perspective of individuals with SCI, several key differences exist. Individuals with SCI were less aware of telemedicine than health professionals, although they rated the desirability of telerehabilitation higher than health professionals. Additionally, individuals with SCI preferred an internet-connected computer service, while health professionals preferred a video system with telemedicine service. It is important to note that these views are reflective of a small subset of the population, rather than the entirety of the population. Further research regarding the efficacy and safety of telerehabilitation is necessary, although there is much interest in this method of rehabilitation.

Outpatient Programs

Dunn et al. (2000) performed an exploratory study of the value of receiving regular, comprehensive outpatient health care follow-up as compared to those who were deemed to have no access to these services. Although this investigation was limited by a poor description of the specific services offered to both the experimental and control groups, there were significant differences in the perceived health, independence, and absence of depression in those seen regularly in outpatient clinics. In addition, this group had significantly less frequent occurrences of specific secondary conditions and also rated the severity of these conditions as less than those having no access to these clinics (Dunn et al., 2000). Although this trial was prospective in nature and attempted a quasi-experimental controlled methodology, the potential confounds (i.e., gender, completeness, race, age, veteran status) varied greatly between the experimental and control groups. In addition, it was uncertain if selection bias may also have been an issue, as the authors did not specify what percentage of individuals within their own service provision cohort refused or did not receive regular outpatient care. These limitations resulted in this study being assessed as having a Level 4 level of evidence.

Similarly, Lugo et al. (2007) (N=42) reported functional and motor outcomes resulting from an interdisciplinary outpatient rehabilitation program for individuals with SCI. On average, patients participated in in-patient rehabilitation that was augmented with 18 months of follow-up (at 1-, 3-, 6-, 12- and 18-month time points). Due to financial constraints in the developing country of Columbia, there was a lack of accessibility to continuous therapy and some functional goals were achieved over the 18-month treatment period. In the absence of protocolized SCI care in developing countries, regular interdisciplinary follow-up and low-cost outpatient service delivery can be effective in achieving functional rehabilitation goals provided provisions are made for program accessibility (i.e., transportation).

Bloemen-Vrencken et al. (2007) conducted a large-scale investigation comparing the utility of a transmural nurse to liaise between community-based patients and health care professionals as compared to routine outpatient care as characterized by periodic visits to a rehabilitation doctor or centre, but results were limited by methodological problems. No differences were seen between a matched sample (n=31 in each group) in terms of the prevalence of secondary complications (i.e., notably pressure sores or UTIs) or associated healthcare utilization over the first year post discharge. The authors noted several limitations with this study, in addition to recruitment issues that resulted in a sample that was half the intended size. Most notably, the implementation of the transmural nurse program was deemed inadequate with nurses making less home visits than was intended. In addition, centres participating in the control condition enhanced their outpatient program mid-study and it was also felt that the follow-up period of one year was too short given the observation that many patients are more consistent in attending follow-up visits during the early post-discharge period but then gradually may lose contact with the rehabilitation centre.

In a pre-post test, Derakhshanrad et al. (Derakhshanrad N, 2015) determined the efficacy of a multidisciplinary outpatient rehabilitation program on functional outcomes in individuals with complete SCI using the Spinal Cord Independence Measure (SCIM III). Upon completion of the program (consisting of educational sessions, OT, PT, and nurse interventions), an overall improvement in functional outcomes was observed from baseline, except for those with higher cervical injuries. However, a lack of comparison with an inpatient rehabilitation program makes it difficult to draw any conclusions about the efficacy of inpatient versus outpatient programs. In light of this, outpatient programs may complement inpatient programs to promote functional recovery. In cases where inpatient programs may not be available (i.e., developing countries), multidisciplinary outpatient programs may be a cost-effective alternative for those with low level, complete SCI.

In another pre-post test, Zinman et al. (2014) evaluated a community reintegration outpatient program for individuals with SCI using a variety of outcome measures assessing well-being, quality of life and participation. Improvements in self-efficacy and positive affect were initially observed, however, these changes were not maintained at follow-up. All other outcome measures were non-significant, which may reflect the need for additional resources following completion of the program. Despite this, qualitative analysis found that participants were satisfied with the program and felt as though they gained relevant knowledge and coping skills necessary for community participation. Although there is a need for community reintegration programs, the clinical utility of this particular program is lacking due to the relatively small sample size and lack of control group. As such, further research is necessary to conclusively demonstrate the efficacy of this program.

Rapidi et al. (2018) published a European evidence-based position paper to guide professional practice in Physical and Rehabilitation Medicine (PRM) for persons with SCI, based on a systematic review of the literature and expert consensus process. The recommendations on aspects related to outpatient and follow-up care, included that:

- Interventions should take place in different PRM settings, according to the phase post-SCI (acute, post-acute, chronic phase): PRM departments in general or university hospitals, PRM departments/centres, specialized SCI centres, community based PRM facilities including home-rehabilitation, where the rehabilitation team is specialized in SCI.

- PRM physicians should organize tele-health interventions and tele-rehabilitation to improve health care provision and continuing rehabilitation in the chronic phase post-SCI, particularly for people with SCI in remote areas.
- PRM physicians should decide the discharge criteria from inpatient rehabilitation facilities and liaise with outpatient facilities taking into consideration the individual needs for each person with SCI such as medical stability, nursing and medical requirements, rehabilitation goal attainment, home and caregiver situation and possibility of transportation.
- PRM physicians should provide life-long monitoring for persons with SCI to look for further functional decline, to detect additional impairments in body functions, activity limitations and participation restrictions.
- A robust system of primary healthcare and/or community based rehabilitation, should be accessible to people with SCI, and offered under the supervision of a PRM physician, including annual comprehensive examinations and appropriate specialized services by the multi-professional rehabilitation team as part of the long-term follow-up and provision of care for persons with SCI.
- PRM physicians should continue long-term follow-up of persons with SCI, also when ageing, aiming to meet the individualized needs of the person using diverse treatment strategies along the lifespan of these persons with a life-long disability

Conclusions

There is Level 2 evidence (from a randomized controlled trial; Dallolio et al. (2008)) supported by level 4 evidence (from one prospective controlled trial; Phillips et al. (1999) and one pre-post test; Shem et al. (Shem et al., 2017)) that telerehabilitation is clinically feasible and may be an adjunct to routine follow-up care for a variety of secondary health complications, leading to improved patient satisfaction and enhance functional outcomes.

There is level 5 evidence (from one observational study; Kim et al. (2012)) that clinicians and individuals with SCI are interested in telerehabilitation, although, some concerns exist regarding the cost and risks (i.e., medical liability) of implementation.

There is limited level 4 evidence (from one prospective controlled trial; Dunn et al. (2000)) that provision of routine, comprehensive, specialist follow-up services may result in perceived improvements of health, independence and less feelings of depression.

There is limited level 4 evidence (from one prospective controlled trial; Bloemen-Vrencken et al. (2007)) that coordination of care through a community-based transmural nurse has no effect on reducing secondary complications and associated health utilization as compared to routine outpatient care consisting of periodic visits to a specialized rehabilitation doctor or centre.

There is level 4 evidence (from one pre-post test; Lugo et al. (2007)) that regular and accessible interdisciplinary follow-up can result in achieving functional goals where protocolized SCI care is unavailable.

There is level 4 evidence (from one pre-post test; Derakhshanrad et al. (2015)) that multidisciplinary outpatient rehabilitation programs may complement inpatient rehabilitation programs and promote functional recovery.

There is level 4 evidence (from one pre-post test; Zinman et al. (2014)) that there is a need for community reintegration programs following SCI, however, further research is necessary to determine the efficacy of such programs.

Routine, comprehensive, specialist follow-up services may result in improved health in individuals with SCI. Multidisciplinary outpatient rehabilitation programs may complement inpatient rehabilitation programs to promote functional recovery in individuals with SCI. In the absence of protocolized SCI care, regular and accessible interdisciplinary follow-up and outpatient care can result in functional goal attainment. Telerehabilitation may enhance patient satisfaction and improve functional outcomes in patients with SCI, although, some concerns exist regarding the cost and risks (i.e., medical liability) of implementation. Individuals with SCI indicate there is a need for community reintegration programs.

8.2 Rehospitalization and Healthcare Utilization after Initial Rehabilitation in SCI

Individuals with SCI face complex and life-long challenges related to secondary health complications. When compared the general population, individuals with SCI are at an increased risk of developing secondary health complications ((Middleton, Lim, Taylor, Soden, & Rutkowski, 2004; Savic G, 2000). The most frequently reported secondary health complications in individuals with SCI include UTI, pressure ulcers, respiratory, cardiovascular and psychosocial issues (Piatt, Nagata, Zahl, Li, & Rosenbluth, 2016). These complications may occur at any time point throughout injury and often lead to rehospitalization and frequent usage of health services (Piatt et al., 2016). Not only are ongoing complications and rehospitalization costly, they often disrupt quality of life, interpersonal relationships and work (Brinkhof et al., 2016). In this sense, there has been much interest in understanding the patterns and antecedents of rehospitalization and healthcare utilization to inform effective preventative strategies.

Table 16. Rehospitalization and Healthcare Utilization

Author Year **Country** **Research Design** **PEDro Score** **Sample Size**	**Methods**	**Outcomes**
	Rehospitalization	
Cai et al., 2018 USA Retrospective Cohort $N_{initial}$=300, N_{final}=300	**Population:** *Hospitalization Cohort (n=212):* Mean age: 57.2±16.4yr; Gender: male=97.9%, female=2.1%, Level of injury: C4 and above=26, C5-C8=25, T1 and below=39: AISA A-C=90, D=105. *Emergency Department Cohort (n=145):* Mean age: 58.2±16.3yr; Gender: male=98.1%, female=1.9%,	Emergency department visits: 1. Within one year of initial rehabilitation, 47% of veterans visited the ED for a total of 168 times, with a mean of 1.16 visits per person. • 42.6% visited an ED once • 30.9% visited twice • 26.5% visited three or more times

<table>
<tr><td></td><td>Level of injury: C4 and above=23, C5-C8=12, T1 and below=26: AISA A-C=61, D=72.
Intervention: No intervention. Retrospective review of veteran affairs (VA) hospital utilization versus non-VS hospital and emergency department utilization in veterans with SCI from 1999 to 2014.
Outcome measures: Emergency Department (ED) visits and hospitalizations.</td><td>2. ED visits were equally distributed between VA and non-VA facilities (44% versus 56%).

Hospitalizations:
1. Within one year of initial rehabilitation, there were 247 hospitalizations among 212 veterans, with a mean of 1.17 hospitalizations per person.
• 51.5% were never hospitalized
• 49.5% experienced at least one hospitalization
• 18.1% were hospitalized twice
• 39.1% were hospitalized three or more times
The majority of hospitalizations were admitted to VA facilities (67%) versus non-VA facilities.</td></tr>
<tr><td>Mashola et al., 2019
South Africa
Retrospective Cohort
$N_{initial}$=543, N_{final}=543</td><td>Population: Age range=7-87yr; Gender: male=407, female=136, Level of injury: paraplegia=331, tetraplegia=208, unknown=4; Severity of injury: complete=317, incomplete=149, unknown=4.
Intervention: No intervention. Retrospective review of readmission rates within 5yr of rehabilitation in patients with SCI in South Africa.
Outcome measures: Readmission rate, cause of readmission.</td><td>1. Of the total population, 100 patients were readmitted.
2. Of the patients readmitted;
o 28 were admitted for a second readmission
o 10 were admitted for a third readmission
o 2 were admitted for a fourth readmission
3. The most common cause of readmission was secondary health conditions (80%), followed by further need for rehabilitation (12%).
4. The most common secondary health conditions were:
o Pressure ulcers (39%)
o Urinary tract infections (12%)
o Deteriorating neurological status (6%)
o Constipation (3%)
Rate of readmission was greater for those with paraplegia than those with tetraplegia (p=.0), as well as those with incomplete injury (p=.001).</td></tr>
<tr><td>Ruediger et al., 2019
USA
Cohort
$N_{initial}$=176, N_{final}=176</td><td>Population: Mean age=44.2±19.9yr; Gender: male=121, female=4, Level of injury: paraplegia=46%, tetraplegia=54%, low tetraplegia=31; Severity of injury: AIS A-C=116, D=27.
Intervention: Specialized medical home care: medication education, one month of discharge medications, proactive phone calls to patients, 24/7 hotline to reach physician/nurses, multidisciplinary outpatient follow-up and proactive case management.
Outcome measures: Hospital readmission and emergency department (ED) visits.</td><td>1. Within the first year following discharge from an inpatient rehabilitation hospital, 30% of individuals were readmitted.
2. Within the first year of SCI onset, 24% were readmitted.
3. Of those admitted, 81% of readmissions were related to SCI.
4. The most common causes for readmission were urologic pathologies (39%), respiratory complications (19%), infections (15%) and cardiovascular problems (11%).
5. Within the first year following discharge from an inpatient rehabilitation hospital, 41% visited the ED.
6. Within the first year of SCI onset, 36% visited the ED.
7. Of visits to the ED, 55% resulted in admission.
Of ED visits that did not result in admission, 85% were related to SCI.</td></tr>
</table>

Sharwood et al., 2019 Australia Retrospective Cohort $N_{initial}$=740, N_{final}=740	**Population:** Mean age=not reported; Gender: male=638, female=102, Level of injury: cervical=161, thoracic=258, lumbosacral=424; Severity of injury: not reported. **Intervention:** No intervention. Retrospective review of health and health service costs related to readmission in patients who sustained work-related traumatic SCI in New South Wales, Australia from 2013-2016. **Outcome measures:** Readmission, reason for readmission, cost of readmission.	1. Within 28 days of discharge, 8% experienced unplanned readmission episodes, with over half relating to a primary diagnosis of care involving rehabilitation. 2. Other reasons for readmission included device complications/infections (7.5%), genitourinary or respiratory infections (10%) or mental health needs (4.3%). The mean readmission cost was $6946±$14 532 per patient.
Skelton et al., 2019 USA Retrospective Cohort $N_{initial}$=2414742, N_{final}=2414742	**Population:** *Inpatient Hospitalizations: Cervical, Quadriplegia (n=690 742)* Mean age=51±33yr; Gender: male=70.3%, female=29.7%; *Thoracic, Lumbar, Sacral, Paraplegia (n=967 273)* Mean age=52±34yr; Gender: male=66.3.3%, female=33.7%. *C (n=690 742)* Mean age=51±33yr; Gender: male=70.3%, female=29.7%. *ED Visits: Cervical, Quadriplegia (n=197 147)* Mean age=46±31yr; Gender: male=75.1%, female=24.9%. *Thoracic, Lumbar, Sacral, Paraplegia (n=398 424)* Mean age=45±31yr; Gender: male=72.1%, female=27.9%. **Intervention:** No intervention. Retrospective review and cost analysis of emergency department (ED) visits and inpatient hospitalizations for genitourinary (GU) complications in patients with SCI from 2006 to 2015. **Outcome measures:** Incidence of GU complication, ED visit, hospitalization, mortality, medical costs.	1. The proportion of SCI-related hospitalizations due to GU complications increased 2.5% annually from 2006 to 2011 and 0.9% from 2011 to 2015. 2. Hospitalized patients tended to be: • Male (57-70%) • Non-Hispanic white (54-64%) • Older than those released from the ED • Principle diagnoses were septicemia (13.4%), rehabilitation care (6.8%) and UTIs (6.7%) 3. Age (55 to 80), level of injury (cervical injuries or quadriplegia) and payer source (underinsured or uninsured) were positively correlated to in hospital mortality. 4. Patients with cervical injuries or quadriplegia were 72% more likely to die in hospital and twice as likely to die during an ED visit. 5. Patients that are uninsured or underinsured were 25% more likely to die in hospital and 67% more likely to die during an ED visit. 6. The costs of GU-relayed health care use exceeded $4 billion over the study period.
Sippel et al. 2018 USA Observational $N_{initial}$=180, N_{final}=125	**Population:** Mean age: 63±12.5yr; Gender: male=121, female=4, Level of injury: paraplegia=39, high tetraplegia=15, low tetraplegia=31; Severity of injury: AIS A=35.2%, C=20%, D=19.2%, E=3.2%, unknown=12.8%. **Intervention:** No intervention. Retrospective review of Spinal cord injury home care program (SCIHCP) on health care utilization and mortality in patients with SCI. **Outcome measures:** VA North Texas Health Care System (VANTHCS) hospital admissions, LOS, Emergency Department (ED) visits, mortality.	1. No significant changes in number of ED visits, number of hospital admissions, or LOS were observed (p>0.05). 2. Increased home care visits and mental health comorbidities significantly predicted more hospital admissions (p<0.05). 3. Older patients and those with more mental health comorbidities were more significantly likely to experience increased LOS (p<0.05). 4. Prediction models were significant after adjusting for injury level, age, race, time since SCI and number of medical comorbidities. 5. More home care visits were significantly associated with lower likelihood of mortality post-enrollment (p<0.05).
Noonan et al. 2014 Canada Observational	**Population:** Traumatic SCI; Mean age: 48.3±13.3yr; mean time since injury: 18.5±13.1yr; Gender: male=806,	1. 26.1% of all participants reported being rehospitalized at least once in the last 12

N=1549	female=331, Injury group: tetraplegia, AIS A/B=229; tetraplegia, AIS C/D=301; paraplegia, A/B=361; paraplegia, C/D=184; unknown=62. **Intervention:** No intervention. Community survey of people with SCI living in Canada. **Outcome measures:** Health care utilization (HCU), categorized into three groups: group 1, did not receive needed care and/or rehospitalized; group 2, received needed care but rehospitalized; and group 3, received needed care and not rehospitalized. Other measures included multimorbidity (number of 30 comorbidities/ complications); secondary health conditions; Short Form-12.	months (with an average length of stay 23.5±46.7 days). 2. Most participants (89.4%) reported seeing at least one health care professional (HCP) in outpatient setting in the previous 12 months. The mean frequency of HCP contact was 32.7±62.0 times, with a mean of 3.5±2.7 different types of HCPs seen. 3. The most common type of HCP seen was a general practitioner (79.5%), followed by an allied health professional (57.6%). Among specialist physicians, seeing a urologist was common (38.6%). Multimorbidity was significantly associated with inappropriate HCU (group 1, did not receive needed care and/or rehospitalized) and together these factors were associated with lower health status.
Ullrich et al. 2013 USA Observational $N_{initial}$=448, N_{final}=286	**Population:** Mean age=53yr; Gender: male=97%, female=3%; Level of injury: T2-S4/S5=49%, C5-T1=38%, C1-C4=13%; Severity of injury: not reported. **Intervention:** No intervention. Standardized psychological evaluations were reviewed from 2005 to 2008 to examine comorbid pain and depression in patients with SCI at a specialty care centre. **Outcome measures:** Medical and demographic information, depression scale, pain scale.	1. Approximately 20% of the sample showed elevated pain and depression at one yr. 2. Patients with elevated pain and depression showed higher scores on those measures than patients with either pain or depression alone. 3. Pain scores were stable over time. 4. Depression scores improved over three years, however, patients with more pain and depression showed less improvement on depression scores that those with depression alone. 5. Presence of pain and depression and pain alone were associated with significantly more inpatient admissions to a SCI specialty centre than for depression alone or neither condition. Presence of pain and depression and depression alone were associated with significantly more outpatient and psychology visits to a SCI specialty centre than for pain alone or neither condition.
Dryden et al. 2004 Canada Case Control $N_{initial}$=233, N_{final}=233	**Population:** Traumatic SCI; Median age: 34.0yr; Gender: males=176, females=57; Level of injury: Cervical=117, Thoracic, Lumbar, Sacral or Cauda Equina=98; Severity: Complete=43, Incomplete=69, Unknown=121. **Intervention:** Retrospective analysis (population-based) of cases of traumatic SCI between 1992-1994 from 5 administrative healthcare databases (Province of Alberta). Control subjects registered with the Alberta health system were matched by age, gender and region at a ratio of 5:1). **Outcome Measures:** Rehospitalization, Health care utilization, mortality and secondary complications followed over a 6yr period post-injury.	1. 57.3% of persons were rehospitalized over the 6 yr follow-up period with a median LOS of 4.0 d/hospital stay. 2. After initial discharge, persons with SCI had 2.6 more hospital visits than matched controls. 3. Persons with SCI had a median # of physician contacts of 22.0 in yr 1, declining to 8.0 by yr 2 and to 4.0 by yr 6. Controls had fewer physician contacts for each year (median =3.0). 4. 20 (8.6%) died during initial hospitalization and 16 (7.5%) died during 6 mo follow-up and this was a greater mortality rate with SCI as compared to controls (p<0.001). Over the 6 yr follow-up 47.6% were treated for a UTI, 33.8% for pneumonia, 19.7% for decubitus ulcer and 15.5% for septicemia.

[Jaglal et al.](#) 2009 Canada Case Series $N_{initial}$=559, N_{final}=559	**Population:** Traumatic SCI; Age: 47.3±18.4 yr; Gender: males=423, females=136; Level of injury: Cervical=350, Thoracic=126, Lumbar=62, Other=21. **Intervention:** Retrospective analysis (population-based) of cases of traumatic SCI between 2003-2006 from six administrative healthcare databases (Province of Ontario). **Outcome Measures:** Rehospitalization rates, causes, predictors collected over a 1-yr period following rehabilitation discharge.	1. 27.5% were rehospitalized to acute care in the 1^{st} yr following initial rehab discharge. 2. Main causes were musculoskeletal (23.1%), respiratory (11.5%), gastrointestinal (11.0%), urological (10.5%), cardiovascular (10.3%), psychological (9%) and skin (7.3%) disorders. 3. Factors significantly associated with 1-yr rehospitalization in multivariate logistic regression were longer length of rehabilitation stay, rural residence, >50 outpatient physician visits and >50 specialist visits following the initial admission. Individual factors with highest likelihood (i.e., highest odds ratios) of being rehospitalized included: Total physician visits ≥ 50 (OR=3.69), Total specialist visits ≥ 50 (OR=2.95), rural residence (OR=1.94), presence of comorbidities with Charlson score ≥ 3 (OR=2.08), >70 years old (OR=1.72). Patients with SCI who were rehospitalized had significantly higher healthcare utilization. They had twice as many total physician and visits with specialists than their counterparts who were not rehospitalized. The mean number of total outpatient physician visits was 49.6 for the rehospitalized group (versus 25.8 for the not-rehospitalized group).
[Jaglal et al.](#) 2009 Canada Case Series $N_{initial}$=559, N_{final}=559	**Population:** Traumatic SCI; Age: 47.3±18.4 yr; Gender: males=423, females=136; Level of injury: Cervical=350, Thoracic=126, Lumbar=62, Other=21. **Intervention:** Retrospective analysis (population-based) of cases of traumatic SCI between 2003-2006 from six administrative healthcare databases (Province of Ontario). **Outcome Measures:** Rehospitalization rates, causes, predictors collected over a 1-yr period following rehabilitation discharge.	4. 27.5% were rehospitalized to acute care in the 1^{st} yr following initial rehab discharge. 5. Main causes were musculoskeletal (23.1%), respiratory (11.5%), gastrointestinal (11.0%), urological (10.5%), cardiovascular (10.3%), psychological (9%) and skin (7.3%) disorders. 6. Factors significantly associated with 1-yr rehospitalization in multivariate logistic regression were longer length of rehabilitation stay, rural residence, >50 outpatient physician visits and >50 specialist visits following the initial admission. Individual factors with highest likelihood (i.e., highest odds ratios) of being rehospitalized included: Total physician visits ≥ 50 (OR=3.69), Total specialist visits ≥ 50 (OR=2.95), rural residence (OR=1.94), presence of comorbidities with Charlson score ≥ 3 (OR=2.08), >70 years old (OR=1.72). Patients with SCI who were rehospitalized had significantly higher healthcare utilization. They had twice as many total physician and visits with specialists than their counterparts who were not rehospitalized. The mean number of total outpatient physician visits was 49.6 for the rehospitalized group (versus 25.8 for the not-rehospitalized group).
[Cardenas et al.](#) 2004 USA Observational $N_{Initial}$=8668, N_{final}=1252	**Population:** SCI: Level of injury: C1-4, C5-8, T1-S5; Severity of injury: AIS: A-D.	1. 90% of patients were discharged home from acute rehabilitation. 2. The most common reasons for rehospitalizations included:

	Intervention: Retrospective analysis of cases of traumatic SCI for persons with anniversary dates of 1, 5, 10, 15 or 20yr post-discharge occurring between 1995-2002 within the United States Model Systems database. **Outcome Measures:** Discharge destination, causes for rehospitalization, predictors of rehospitalization.	• Diseases of the genitourinary system. • Diseases of skin and subcutaneous tissue. • Diseases of the respiratory system. • Other unclassified diseases. • Diseases of the musculoskeletal system. 3. At first yr follow up the average number of rehospitalizations were significantly higher than other follow-up yr (p<0.001). Rate was 55% in first yr and 36-38% thereafter. 4. Rehospitalization rates were not significantly different among the different age groups. 5. At 1 yr follow-up, rehospitalization was significantly related to: • Lower motor FIM scores (p=0.000). • Patients funded by state or federal programs (p=0.010). 6. At 5 yr follow-up, rehospitalization was significantly related to: • Lower motor FIM scores (p=0.000). • Race, with Hispanics (p=0.009) and other races (p=0.027) were less likely than African Americans. At 10 yr follow-up, only payer remained significantly related to rehospitalization rates (p=0.004).
Charlifue et al. 2004 USA Case Series $N_{initial}$=7981, N_{final}=7981	**Population:** Traumatic SCI: Age n=3254 ≤40 yr, 2908 ≥41 yr; Level of injury: All levels; Severity of injury: AIS: A-D. **Intervention:** Retrospective analysis of cases of traumatic SCI with onset between 1973-1998 from the United States Model Systems database. **Outcome Measures:** Number and causes of rehospitalization, days rehospitalized, number of pressure ulcers, self-assessed health status and Satisfaction with Life Scale collected at 1, 5, 10, 15, 20 and 25yr post-injury.	1. Rate of rehospitalization was 41% in yr 5 and significantly less (35-36%) thereafter (p=0.000) 2. Average number of days rehospitalized was highest at year 5 (6.0 days) and significantly less thereafter in a progressive fashion (from 5.4 days at year 10 to 3.7 days by year 25). (p=0.002) 3. Perceived health status and SWLS was generally high and pain scores generally low Both # of rehospitalizations and a greater # of days rehospitalized were predicted by being older at injury, being unmarried, having an indwelling catheter, having a more severe SCI and having been hospitalized 5 years earlier.
Middleton et al. 2004 Australia Case Series N_{inital}=432, N_{final}=432	**Population:** Individuals with SCI rehospitalized between 1990-1991, 1999-2000; Traumatic SCI; Gender: males=338, females=94; Level of injury: paraplegia=199, tetraplegia=229, unclassified=4; Severity of injury: AIS: A=206, B=27, C=67, D=132. **Intervention:** Data from spinal cord injured patients was retrospectively analyzed. **Outcome Measures:** Causes for rehospitalization, predictors of rehospitalization.	1. 253 persons (58.6%) (≥12 months post injury) required rehospitalization for a spinal-related cause on at least one occasion during the 10yr study period (total readmissions =977; 15,127 bed-days; avg length of stay =15.5d; median 5d). 2. ~ 10% were readmitted five times or more. 3. Overall rehospitalization rate in the first 12 mo post discharge =0.64 readmissions per person at risk and decreases to ~0.4 readmissions per person at risk 10yr post acute admission). 4. Average length of stay was significantly longer for those with AIS A, B and C (22.2 – 17.0 d) compared to AIS D (11.3 d). 5. The most common causes for rehospitalization included: • Complications of the genitourinary system (n=235 (24.1%)), (125 persons (28.9%))

		• Gastrointestinal (GIT)-related (n=107 (11.0%)), (69 persons (16.0%)) • Skin pressure areas (n=87 (8.9%)), (40 persons (9.3%)) • Musculoskeletal (n=84 (8.6%)), (60 persons (13.9%)) • Other causes included Neurological (n=30 (3.1%)); Respiratory (n=44 (4.5%)); Cardiovascular (n=47 (4.8%)); Endocrine (n=7 (0.7%)); Psychiatric (n=66 (6.8%)); Other (n =270 (27.6%)) 6. The costliest cause of readmission in terms of bed-occupancy, were the skin-related complications (pressure sores: 6.6% of all readmissions, accounted for 27.9% of bed-days and average length of stay=65.9 d) 7. Depending on the complication, age and level and completeness of neurological impairment influenced differential rates of readmission; AIS D=43.2%; AIS A, B and C=55.2-67.0% (p<0.0001) 8. Mean duration to first readmission=46 mo (AIS A-C=26-36 mo, AIS D=60 mo). Overall rehospitalization (and bed occupancy) rates trended downwards over time, yet rates were high in the first 4 yr after discharge (0.64 readmissions per person, 12.6 bed-days) before decreasing to 0.35 (2.0 bed-days) as the 10th yr approached.
Franceschini et al. 2003 Italy Case Series $N_{initial}$=251, N_{final}=146	**Population:** All individuals with SCI hospitalized 1989-1994. Mean age =37.8 yr; Gender: males=104, females=42; Level of injury: Cervical=36.4%, Thoracolumbar=63.7%; Severity of injury (Frankel): A=44.6%, B=2.7%, C=13%, D=39.7%; Time since injury=6.1 yr; Traumatic =74.7%, Non-traumatic 25.3%. **Intervention:** Cross-sectional telephone questionnaire of various rehabilitation outcomes. **Outcome Measures:** Custom questionnaire including rehospitalization among other things (i.e., state of health, occupation, mobility, autonomy, social and partner relationships, satisfaction with QoL) collected at mean of 6.1 yr post-discharge.	25.3% respondents had been hospitalized once in the past year, most frequently for urological problems (22.9%), spasticity (11.4%) and rehab treatment (11.4%).
Savic et al. 2000 UK Case Series $N_{initial}$=198, N_{final}=198	**Population:** Mean age: 57.5 yr; Gender: males =84.8%, females=15.2%; Level and severity of injury (AIS): paraplegic ABC=97, tetraplegic ABC=61, D=40; Time since injury=33 yr. **Intervention:** Individuals with SCI were interviewed three times 1990-1996 and their medical records were reviewed.	1. 64% of patients had 1 or more readmissions between 1990 and 1996. 2. Mean length of stay per readmission was 12.03d. 3. Reasons for readmission included: • Urinary system complications (40.5%). • Skin problems (17%). • Digestive system (10%). • Musculoskeletal system (8.7%). • Nervous system complications (6.9%).

	Outcome Measures: Readmission rates, reasons for readmission, LOS, FIM score, CHART score.	4. Highest reason for bed occupancy was skin problems. 5. No significant difference in readmission rates was seen in: • Level of injury of the patients. • Current age of patients. 6. Patients with Frankel/AIS grade D had significantly shorter LOS than patients with A, B or C grade (p=0.005). 7. There was significant difference between hospitalized patients and non-hospitalized patients in: • Patients hospitalized were paralyzed for 2yr longer than the non hospitalized group (p=0.012). • Hospitalized patients had a lower FIM score than non-hospitalized (p=0.031). Hospitalized patients had a lower CHART physical independence score (p=0.003) and CHART occupation score (p=0.001).
Healthcare Utilization		
Ronca et al., 2020 Switzerland Observational $N_{initial}$=1294, N_{final}=1294	**Population:** Median age=57yr; Gender: male=918, female=376, Level of injury: paraplegia=811, tetraplegia=341; Severity of injury: complete=416, incomplete=736. **Intervention:** No intervention. Community survey of facilitators and barriers to using SCI-specialized outpatient and inpatient care from the Swiss Spinal Cord Injury Cohort Study conducted between 2017 and 2018. **Outcome measures:** attendance of annual check-up at SCI-specialized treatment facility, utilization of SCI-specialized outpatient care, utilization of SCI-specialized inpatient care.	1. In the last 12 months, 51% of the participants attended their annual check-up, 33% utilized SCI-specialized outpatient care, 44% were hospitalized at a SCI center.
Martini et al., 2020 Germany Observational $N_{initial}$=1479, N_{final}=1479	**Population:** Mean age=55.3±14.6yr; Gender: male=1076, female=401, Level of injury: paraplegia=730, tetraplegia=696; Severity of injury: complete=489, incomplete=964. **Intervention:** No intervention. Survey to determine the utilization of physical therapy and occupational therapy following SCI, over a period of 12mo. **Outcome measures:** Physical therapy and occupational therapy utilization.	1. In the past 12mo, 78.1% received physical therapy and 29.3% received occupational therapy. 2. Physical therapy and occupational therapy were significantly associated with time since SCI occurrence, participation in lifelong care programs, and electric wheelchair dependency (p<.05). 3. SCI characteristics, level of impairment and time since SCI had a greater impact on occupational therapy than on physical therapy utilization.

Jakimoversuska et al. 2017 Norway Observational $N_{initial}$=165, N_{final}=147	**Population:** Mean age: 50±9yr; Gender: male=120, female=27, Level of injury: tetraplegia=53, paraplegia=94; Severity of injury: AIS A=99, B=11, C=11, D=18, E=5. **Intervention:** No intervention. Retrospective review of health-status/psychological distress and self-reported utilization of healthcare services in patients with SCI (interviewed in 2004/05). **Outcome measures:** Health service use and satisfaction, General Health Questionnaire-20 (GHQ-20).	1. Most participants received SCI follow-up health services at least once after their initial rehabilitation; 34% were satisfied, 51% neutral, and 18% not satisfied with services received. 2. 34 cases of psychological distress were identified using the GHQ-20. These cases did not significantly differ from non-cases in terms of demography, time since injury, cause of injury, injury severity, marital status or employment status.
Amsters et al. 2014 Australia Observational $N_{initial}$=270, N_{final}=193	**Population:** Mean age: 43yr; Gender: male=159, female=34, Level of injury: paraplegia=87, tetraplegia=106; Severity of injury: AIS A=83, B=20, C=16, D=74. **Intervention:** No intervention. Analysis of general practitioner (GP) utilization patterns in individuals with SCI, over a 5yr period. **Outcome measures:** General Practitioner use.	1. Compared to the general population, young men with SCI used GP services significantly more ($p<0.05$). 2. Individuals with paraplegia used GP services significantly more than individuals with tetraplegia ($p<0.05$). 3. There is a need for specialist SCI outreach teams.
Noreau et al. 2014 Canada Observational $N_{initial}$=1549, N_{final}=1549	**Population:** Mean age: 49.6±13.9yr; Gender: male=67.2%, female=32.8%, Level of injury: paraplegia=57.8%, tetraplegia=42.2%; Severity of injury: AIS A=36.7%, B=7.5%, C=19.5%, D=20.6%, E=2.4%, unknown=13.3%. **Intervention:** No intervention. Survey examining the life situation of people with SCI living in Canada. **Outcome measures:** Community survey examining demographic, health, SCI-specific needs, community participation, employment, quality of life, health care utilization, satisfaction and overall health.	1. SCI-specialized health care needs met in 60% and 65% of individuals with traumatic and non-traumatic injuries, respectively. 2. Some major needs for services to support community living (e.g., equipment and technical aids, health care, transportation, and accessible housing) are met for 75% of a population living with SCI. This proportion decreased to less than 50% for individuals requiring income support, healthy living, emotional counselling or job training. 3. Complications are highly prevalent for some health issues, including pain, sexual dysfunction, spasticity, UTI and musculoskeletal disorders. 4. Extent of community participation varies tremendously among daily activities and social roles based on values and preferences. 5. Some dimensions of quality of life are rated positively (e.g., family life) while others are disrupted (e.g., sex life and physical health). 6. 13.2% of Individuals receiving general care and 14.7% of individuals receiving SCI-specialized care are somewhat or very dissatisfied with the ability of government agencies, community and other organizations ability to meet their needs. 7. These findings varied significantly between people with traumatic and non traumatic lesions ($p<0.05$).
Stillman et al. 2014 USA Observational $N_{initial}$=108, N_{final}=108	**Population:** Mean age: 48±14yr; Gender: male=55.6%, female=44.4%, Level of injury: tetraplegia=43.5%, paraplegia=52.8%; Severity of injury: complete SCI=61.1%, incomplete SCI=38%; Time since injury: 18±13yr.	1. All but one participant had visited a primary care provider within the past 12 mo and 85% had ≥1 visit to speciality providers. 2. Accessibility barriers were encountered during both primary care (91.1%) and specialty care (80.2%) visits.

	Intervention: No intervention. Observational study using an internet-based survey to determine to healthcare utilization and barriers experienced by individuals with SCI. **Outcome measures:** Health care utilization during the past year, barriers encountered when accessing health care facilities, and receipt of routine care and preventative screenings.	3. The most prevalent barriers were inaccessible examination tables (primary care 76.9%; specialty care 51.4%) and lack of transfer aids (primary care 69.4%; specialty care 60.8%), as well as lack of staff capable of assisting with patient transfers (in about 40%). 4. Most participants had not been weighed during their visit (89%) and had been examined while fully clothed and sitting in their wheelchair (85.2%). 5. A high proportion of individuals did not receive routine and preventive screening tests, including colonoscopy over 50 years of age (40%), mammogram in women aged over 50 years within last year (60%), Pap smear within previous 3 years (40%), or ever had a bone density scan (55%).
Guilcher et al. 2013 Canada Observational $N_{initial}$=1515, N_{final}=1217	**Population:** Mean age=49.5±19.1yr; Gender: male=912, female=305; Level of injury: cervical=773, thoracic=277, lumbar=127, other=40; Severity of injury: not reported; Time since injury: 6yr period following injury. **Intervention:** No intervention. Retrospective analysis of administrative data sets from 2003-2009 to determine the patterns and characteristics of emergency department visits (ED) in individuals with SCI. **Outcome measures:** Number of emergency department (ED) visits by year post-injury, acuity level, timing of visits, reasons for visits.	1. The total number of ED visits over 6-yr period was 4403, 1443 (33%) as low acuity and 2208 (50%) as high acuity. 2. Of the total number of visits, 752 (17%) were classified as potentially preventable, with the majority of these related to UTI (51.2%), followed by pneumonia (12.1%). 3. The majority of individuals, regardless of acuity level, did not see a primary care practitioner on the day of the ED visit. 4. The number of visits was higher in the first year following injury, with 110 visits per 100 persons (45.3% of sample visited the ED), and remained substantially high up until 6 years following injury (34.5% of sample 6yr post-injury visited ED). 5. Differences in ED patterns were observed based on the rurality index, as higher ED use was noted for individuals living in rural areas compared with those in more urban settings.
Guilcher et al. 2010 Canada Case Control $N_{initial}$=1562, N_{final}=1562	**Population:** Non-traumatic (n=1002) and Traumatic (n=560) SCI; Age at admission: 46.9±17.3 and 61.6±15.8yr; Gender: males =75.4% and 52.2%, females =24.6% and 47.8%; Level of injury: Paraplegia =38.6% and 39.5%, Tetraplegia =47.1% and 18.6%, Other =14.3% and 41.9%. **Intervention:** Retrospective analysis (population-based) of cases of traumatic SCI between 2003-2006 from 3 administrative healthcare databases (Province of Ontario). **Outcome Measures:** Health care utilization collected over a 1yr period following rehabilitation discharge. Predictors of health care utilization included length of stay in rehab, FIM score, rurality index, comorbidities (Charlson Index), Socioeconomic Status.	1. Mean number of overall physician visits was 31.2 and 29.7 for non trauma and trauma respectively. 16.5 and 17.0 for specialist visits. In both cases there was no significant difference in number of visits between non-traumatic and traumatic although there were differences in the types of physicians being visited. 2. Individual factors with highest likelihood (i.e., highest odds ratios) of ≥ 30 physician visits included: lowest quartile FIM @ discharge (OR=1.83), urban (OR=1.59), comorbidities (OR=1.56), ≥ 60 yr old (OR=1.54). 3. Individual factors with highest likelihood (i.e., highest odds ratios) of ≥ 20 specialist visits included: comorbidities (OR=2.05), urban (OR=1.92), paraplegia (OR=1.53), lowest quartile FIM @ discharge (OR=1.51).
Munce et al. 2009 Canada Observational	**Population:** Traumatic SCI; Age: 47.3±18.4yr; Gender: males=423, females=136; Level of injury:	**1.** Mean number of physician visits during the first yr after injury onset was 31.7.

$N_{initial}$=936, N_{final}=559	Cervical=350, Thoracic=126, Lumbar=62, Other=21. Severity of injury: not reported. **Intervention:** No intervention. Retrospective review of physician utilization patterns (family physicians (FPs), specialist and emergency department visits) 1-yr after initial injury in population-based cohort of cases of traumatic SCI between 2003/04-2005/06 from 5 administrative healthcare databases (Province of Ontario). **Outcome Measures:** Physician utilization (including family physician, specialist, emergency physician, etc.), rurality index, comorbidities (Charlson Index) collected over a 1-yr period following rehabilitation discharge.	2. Women had significantly more physician visits than men (37.0 versus 30.0, p=0.006) 3. FPs has the greatest number of visits, followed by physiatrists. 4. Women had significantly more visits to their family physician than men (15.4 versus 10.3, p<0.001) 5. Men had significantly more visits to their physiatrists than women (6.6 versus 4.5, p<0.028) 6. Individual factors with highest likelihood (i.e., highest odds ratios) of 50 or more physician visits included: >70 years old (OR=3.64), direct discharge to chronic care (OR=3.62), in-hospital complication (OR=2.34), thoracic injury level (OR=1.81), direct discharge to rehabilitation (OR=1.69). 7. Individual factors with highest likelihood (i.e., highest odds ratios) of 50 or more specialist visits included: direct discharge to chronic care (OR=11.52), direct discharge to rehabilitation (OR=2.45), in-hospital complication (OR=1.99). 8. Only rurality significantly predicted two or more visits to the emergency department (p<0.05).
Dorsett & Geraghty 2008 Australia Case Series $N_{initial}$=53, N_{final}=46	**Population:** Mean age=32yr; Gender: males =42, females=4; Level of injury: paraplegia=19, tetraplegia=27; Severity of injury: complete=16, incomplete=30. **Intervention:** 10yr data from those with acute traumatic SCI discharged from the Spinal Injuries Unit of the Queensland Spinal Cord injuries Service from November 1992 to March 1994 was assessed. **Outcome Measures:** Mortality, Life situation questionnaire, medical service utilization, hospital admission (including reason for admission) and occurrence of pressure sores collected at discharge, 12mo, 24mo, 36mo and 10yr.	1. 9% mortality rate was seen within 3 yr of study. 2. Life situation questionnaire mean scores remained consistent over the 10 yr. 3. The highest percentage of medical service utilization (10 or more) was at 2 yr, while the lowest was at the 10th yr (only 3) 9%. 4. No significant change was seen in the number of hospitalizations or length of stay over time. 5. Overall 32% of patients were rehospitalized in the first 2 yr and 52% by the 10th yr. 6. Only 11% of individuals required rehospitalization for longer than 28 d. 7. Common reasons for rehospitalization included: pressure sores, UTI, bowel obstructions, pneumonia, surgical removal spinal instrumentation, fractures and renal tract calculi. 8. At 2 yr, reasons for rehospitalization were directly related to SCI, while at 10th yr SCI complications were not related to rehospitalization. 9. Pressure sore occurrence was highest at the 2nd yr, however no significant change in the number of pressure sores occurred over time. Half the patients reported no pressure sores over the study period, while 30% tended to have pressure sores at multiple points of time.
Donnelly et al. 2007 United States, Canada and United Kingdom Observational $N_{initial}$=373, N_{final} =373	**Population:** Community survey: Mean age (combined sample)=58.7±9.5yr; mean time since injury=35.9±7.5yr; Gender: males=315, females=56; Injury group: tetraplegia, AIS A-C=130;	1. Almost all individuals (93%) reported having a family doctor, whereas only two-thirds had a spinal injuries specialist (63%) and 56% had both a family doctor and spinal injuries specialist.

	paraplegia, AIS A-C =160; All AIS D lesions=76. **Intervention:** No intervention. Cross-sectional study of long-term health following a spinal cord injury, with comparison across three distinct health-care delivery models in Canada, United States and United Kingdom. **Outcome Measures:** Health Care Questionnaire to measure utilization, access and satisfaction with health services.	2. About half (49%) of sample saw another medical specialist besides the spinal injuries specialist. 3. The average number of specialist contacts/yr was 1.5. 4. Over two-thirds of individuals consult their family doctor for new problems, spinal cord injury-related problems (such as fatigue, pain, bowel and bladder problems), preventive health services (annual physical, female breast exam, blood tests and urine specimen) and personal problems. 5. Unique items for spinal injuries specialists are routine rehabilitation follow-up, urinary ultrasound and neurological exam. 6. In more than 75% of participants, issues such as sexual health, alcohol use, community functioning and emotional issues were not addressed by either family doctor or spinal injuries specialist. 7. Significant differences were found in utilization among Canada, United States and UK, with Canadians most likely to receive health care from family physicians and Americans most likely to receive care from specialists. Access to and satisfaction with health services were similar.

Discussion

Rehospitalization

Due to differences in methods of data collection, duration of follow-up, calculation of readmission rates, specific inclusion criteria and regional healthcare systems (i.e., Australia, Canada, Italy, Turkey, United Kingdom, United States), direct comparison of the articles included for review is challenging. However, it is clear that hospital readmission is a significant issue across all regions, with universally high rehospitalization rates (Cai et al., 2020; Cardenas, Hoffman, Kirshblum, & McKinley, 2004; Charlifue, Lammertse, & Adkins, 2004; P. Dorsett & Geraghty, 2008; Dryden et al., 2004; M. Franceschini, Di Clemente, Rampello, Nora, & Spizzichino, 2003; Jaglal et al., 2009; Middleton et al., 2004; Paker et al., 2006; Savic G, 2000).

Cardenas et al. (Cardenas et al., 2004) noted an average rehospitalization rate of 55% (defined as the number of patients rehospitalized within a particular anniversary of injury year) for the first-year post-injury and then rates of 36-38% from 5-20 years post-injury. This analysis was conducted using the multi-centre United States model systems dataset (n=8668) between 1995-2002. Similarly, Charlifue et al. (Charlifue et al., 2004) reported that 41% of patients were rehospitalized within five years following injury. Eventually this reduced to 35-36% in the years thereafter, which was not surprising as they both used the same database, albeit, over different years (1973-1998).

Jaglal et al. (Jaglal et al., 2009) defined rehospitalizations as occurring within the first year following initial rehabilitation discharge; thereby, circumventing the primary limitation of most other studies that have a variable follow-up period. Additionally, multiple administrative healthcare databases were linked to overcome variances observed with self-reported data. The authors reported a rehospitalization rate of 27.5% -approximately half that reported in the United States. Likewise, Dorsett and Geraghty (P. Dorsett & Geraghty, 2008) reported similar rates over a similar time period in Queensland, Australia, with 36.6% over the first two years and 52% by year 10.

Middleton et al. (Middleton et al., 2004) reported a slightly higher 10-year rehospitalization rate in New South Wales, Australia, with 58.6% of persons rehospitalized due to a SCI-related issue and an additional 10.8% admitted for a non-SCI-related issue. This is consistent with a study from Canada by Dryden et al. (Dryden et al., 2004), who reported a rehospitalization rate of 57.3% for persons with SCI over a 6-year follow-up period. In another study, Savic et al. (Savic G, 2000) longitudinally interviewed community dwelling individuals with SCI three times over six years. Similarly, they reported an overall re-admission rate of 64%.

Overall, it appears as though rehospitalisation rates tend to decline in the first two years following discharge (Cardenas et al., 2004; Charlifue et al., 2004; Middleton et al., 2004). However, in the United States rehospitalisation rates within the first year post discharge tend to be higher than other regions (i.e., Australia and Canada). It is difficult to speculate why this may be given the variation between these countries in terms of health care and social systems. However, this may be related to a shortened rehabilitation stay, as the United States has the shortest rehabilitation LOS compared to any other jurisdiction reporting data (Cardenas et al., 2004).

Across several studies, the primary reasons for hospital readmission following inpatient SCI rehabilitation are consistent (Cardenas et al., 2004; P. Dorsett & Geraghty, 2008; Dryden et al., 2004; M. Franceschini et al., 2003; Jaglal et al., 2009; Mashola, Olorunju, & Mothabeng, 2019; Middleton et al., 2004; Paker et al., 2006; Ruediger, Kupfer, & Leiby, 2019; Savic G, 2000; Sharwood et al., 2019; Skelton et al., 2019). All studies reported issues associated with skin (e.g., pressure ulcers) and the genitourinary system (e.g., UTIs and to a lesser extent complications of the upper urinary tract) as the most frequent reasons for readmission. The impact of pressure ulcers is even more consequential when taking into account the subsequent long LOS for treatment, specialized equipment, care, dressings and surgery, often associated with this specific complication (Middleton et al., 2004; Savic G, 2000).Other issues that were associated with significant rates of readmission included respiratory issues (e.g., infections, especially in persons with tetraplegia), musculoskeletal complaints (e.g., spasticity, pain) and digestive system problems (e.g., bowel). Of note, musculoskeletal issues were the most prominent cause of readmission within the first year post-discharge from rehabilitation (Jaglal et al., 2009), with twice as many admissions than any other issue.

Upon regression analysis of the United States Model Systems dataset, Cardenas et al.(Cardenas et al., 2004) reported that the two most significant predictors of rehospitalization within the first year were motor FIM scores at discharge and the payer (i.e., those with lower motor score state or federal funded persons versus those with private insurance were more likely to be hospitalized). Additionally, predictors of readmission later included the payer, motor FIM and race. A similar analysis was conducted by Jaglal et al.(Jaglal et al., 2009) and the factors most significantly associated with rehospitalization in the first year were longer length of rehabilitation stay, rural residence, 50 or more outpatient physician visits and 50 or more specialist visits following the initial admission. Charlifue et al. (Charlifue et al., 2004) noted that both the number and length of rehospitalizations were predicted by older age at injury, increased severity of SCI, marital status (unmarried), presence of an indwelling catheter and hospitalization within 5 years. Middleton et al. (Middleton et al., 2004) reported shorter times to readmission in individuals with more severe impairment, with AIS grades A-C readmitted between 26-36 months and AIS grade D readmitted within 60 months.

Healthcare Utilization

Individuals with SCI utilize many aspects of the healthcare system more frequently than others, especially in the first year following rehabilitation discharge. Three Canadian studies determined the rates of physician contacts for persons with SCI returning to the community following initial rehabilitation. Guilcher et al. (Guilcher et al., 2010) and Munce et al. (Munce et al., 2009) examined several Ontario administrative healthcare databases and found similar numbers of overall physician visits for those with non-traumatic versus traumatic SCI. However, differences were observed in the types of physicians seen between the two groups. Women with SCI had significantly more physician visits than men in the first year following discharge and were more likely to visit their family physician, whereas men had significantly more visits to their physiatrist (Munce et al., 2009). Additionally, several individual factors were associated with a greater likelihood of physician visits including age, lower FIM scores, discharge to chronic care or other rehabilitation facility, urban versus rural residence or the presence of comorbidities/prior (in-hospital) complications (Guilcher et al., 2010; Munce et al., 2009). Using similar methodologies, Dryden et al. (Dryden et al., 2004) found the median number of physician visits was significantly higher in the first year. This is supported by Ronca et al. (2020), who found that 51% of participants attended their annual check-up within the first year. However, this declined dramatically by year two and year six. In all cases, age, gender and geographically matched control subjects had significantly fewer physician visits each year. While no long-term data is available for physical and occupational therapy use, Martini et al. (2020) found that 78.1% of individuals received physical therapy within 12 months, and only 29.3% received occupational therapy. This is likely due to differences in SCI characteristics, level of impairment and time since injury.

In Australia, a 5-year longitudinal study examining utilization patterns of Medicare-funded services in a randomly selected sample of 193 individuals with SCI, found substantially higher rates of family physician visits in comparison to the general population, matched for age and gender (Amsters et al., 2014). Young men (25-34 years) were found to have the highest utilization. Interestingly, individuals with motor complete paraplegia were found to have the greatest need for primary health care, which may reflect increased autonomy, mobility and less environmental barriers, or perhaps how persons with tetraplegia may access services differently (e.g., through public hospital clinics).

Donnelly et al. (Donnelly et al., 2007) compared services received from family physicians and spinal injury specialists in the United States, Canada and the United Kingdom, as well as the level of accessibility and satisfaction with those services in individuals aging with a chronic SCI. The authors reported that individuals with chronic spinal cord injuries seek out suitable primary healthcare and preventive services in variable ways, depending on the health delivery model. While the family doctor was the first choice for most people irrespective of country, significantly different utilization patterns emerged. Canadians were most likely to receive health care from family physicians, while Americans were most likely to receive care from specialists. Areas of service overlapped for ongoing spinal-related issues, such as bowel and bladder problems, and pain. However, concerns such as sexual health, alcohol use, functioning in community and at work, relationships and emotional issues were not addressed by either the family doctor or a spinal injuries specialist in 75% of the respondents.

More recently, Noonan et al. (Noonan et al., 2017) conducted a large community survey of 1549 people with SCI living in Canada and found that almost 90% of individuals visit their general practitioner yearly, while only 16% visit a physiatrist and 7.5% have SCI peer support. They demonstrated that multimorbidity and inappropriate healthcare utilization were associated with lower physical and mental health status, as well as lower quality of life. These authors proposed that individuals at risk of inappropriate health care utilization (e.g., rehospitalization, not able to access care) should be flagged and their complex health needs addressed proactively by an interdisciplinary team. They suggested that a yearly check-up with such team and the initiation of self-management programs may prevent long-term health problems and visits to an emergency department for preventable and low acuity conditions. Other researchers have also reported high rates of emergency department use for low acuity and potentially preventable conditions, suggesting that the emergency department may be used as an improper substitute for primary care for individuals with traumatic SCI up to 50% of the time (Guilcher, Craven, Calzavara, McColl, & Jaglal, 2013). In particular, rurality was noted to be a significant predictor of emergency department utilization, reflecting that access to and availability of primary care physicians is more challenged in rural than in urban centres.

Despite several studies demonstrating that most people with SCI had visited a primary care provider and/or specialty care provider within the previous 12 months, around 20-25% of people are not satisfied with the service they received (Donnelly et al., 2007; Jakimovska, Kostovski, Biering-Sorensen, & Lidal, 2017). Similarly, in a national SCI survey of Canada, Noreau et al. (Noreau, Noonan, Cobb, Leblond, & Dumont, 2014) reported around 13-15% of individuals receiving specialized or general care are somewhat or very dissatisfied with support received from government agencies, community and other organizations. In a survey of 108 wheelchair-dependent individuals living with SCI in the community, Stillman et al. (2014) reported that accessibility barriers were encountered during both primary and specialty care visits. The most prevalent barriers were inaccessible examination tables, lack of transfer aids and lack of staff capable of assisting with patient transfers. Most participants had not been weighed during their visit and had been examined while fully clothed and sitting in their wheelchair. Additionally, a high proportion of individuals did not receive routine and preventive screening tests, including colonoscopy over 50 years of age, mammogram in women aged over 50 years within last year, Pap smear within previous 3 years, or ever had a bone density scan.

Sippel et al. (Sippel et al., 2019) reviewed outcomes of veterans with SCI/D in the United States, who received a specialized home care program that included a comprehensive annual assessment and at least one home visit by a physician along with 1-2 monthly visits by a registered nurse, as well as by a social worker as needed. Although there were no changes in the number of emergency department visits, number of hospital admissions or LOS after the program, increased home care visits and mental health comorbidities significantly predicted more hospital admissions. Ullrich et al. (Ullrich et al., 2013) showed that the combined presence of pain and depression or pain alone significantly predicted more admissions to a specialized centre than did depression alone or having neither condition.

Most recently, Rapidi et al. (Rapidi et al., 2018) published a European evidence-based position paper to guide professional practice in Physical and Rehabilitation Medicine (PRM) for persons with SCI, based on a systematic review of the literature and expert consensus process. The recommendations on aspects of health promotion, long-term follow-up and early intervention to reduce rehospitalisation and unwarranted healthcare utilization after rehabilitation, included that:

- PRM physicians monitor closely for complications and at a minimum annually review person with SCI for neurogenic bladder dysfunction and their overall health status.
- long-term follow-up, prevention and management of secondary complications (including pressure ulcers, neurogenic bladder and bowel dysfunction, spasticity, neuropathic and nociceptive pain, heterotopic ossifications, osteoporosis, sarcopenia, low energy fractures, orthostatic hypotension, cardiovascular and respiratory function including

autonomic dysreflexia, sexuality-reproductive issues) is dealt with by the PRM physician and the multi-professional rehabilitation team.

- A robust system of primary healthcare and/or community-based rehabilitation, accessible to people with SCI, is offered, under the supervision of PRM physician, including annual comprehensive examination and appropriate specialized services by the multi-professional rehabilitation team as part of the long-term follow-up and provision of care for persons with SCI.
- PRM physicians continue long-term follow-up of persons with SCI, also when ageing, aiming to meet the individualized needs of the person using diverse treatment strategies along the lifespan of these persons with a life-long disability (see also EBPP for ageing persons with disabilities).

Conclusions

Across several studies there is level 2 evidence (from one cohort study; (Cai et al., 2020)), level 3 evidence (from one case control study; Dryden et al. 2004), level 4 evidence (from seven case series; (Charlifue et al., 2004; P. Dorsett & Geraghty, 2008; M. Franceschini et al., 2003; Jaglal et al., 2009; Middleton et al., 2004; Paker et al., 2006; Savic G, 2000) and level 5 evidence (from one observational study; (Cardenas et al., 2004)) that hospital readmission is a significant issue for individuals with SCI in all regions.

There is level 5 evidence (from two observational studies; (Cardenas et al., 2004; Charlifue et al., 2004) and level 4 evidence (from one case series; (Middleton et al., 2004) that hospital re-admission rates are highest in the first year post injury and then tend to decline in the first two years following injury.

There is level 4 evidence (from two case series; (P. Dorsett & Geraghty, 2008; Jaglal et al., 2009) that rehospitalization rates stabilize at a significantly high rate over time.

There is level 2 evidence (from four cohort studies; (Mashola et al., 2019; Ruediger et al., 2019; Sharwood et al., 2019; Skelton et al., 2019)), level 3 evidence (from one case control; (Dryden et al., 2004) supported by level 4 evidence (from 6 case series; (P. Dorsett & Geraghty, 2008; M. Franceschini et al., 2003; Jaglal et al., 2009; Middleton et al., 2004; Paker et al., 2006; Savic G, 2000) and level 5 evidence (from one observational study; (Cardenas et al., 2004) that urinary problems (UTIs), pressure ulcers, respiratory infections and musculoskeletal problems are consistently among the most frequent causes of emergency department visits and hospital readmissions in persons with SCI.

There is level 4 evidence (from three case series; (Charlifue et al., 2004; Jaglal et al., 2009; Middleton et al., 2004) and level 5 evidence (from two observational studies; (Cardenas et al., 2004; Sippel et al., 2019) that factors such as increased age, lower motor function, greater severity of injury, prior contact with the health system, rural habitation, mental health comorbidities and being unmarried are associated with a greater risk of hospital readmission.

There is level 3 evidence (from one case control study; (Guilcher et al., 2010) supported by level 5 evidence (from two observational studies; (Guilcher et al., 2013; Munce et al., 2009) that several factors are associated with a greater likelihood of physician visits including older age, lower FIM scores, discharge to chronic care or other rehabilitation facility, rural residence, comorbidities or in-hospital complications.

There is level 3 evidence (from one case control study; (Dryden et al., 2004) supported by level 5 evidence (from one observational study; (Amsters et al., 2014)) that persons with SCI have an increased number of physician contacts as compared to matched controls from the general population, especially in the first year post-injury.

There is level 5 evidence (from four observational studies; (Amsters et al., 2014; Donnelly et al., 2007; Munce et al., 2009; Noonan et al., 2017) that individuals with chronic SCI seek out family physicians rather than specialists, irrespective of country. However, many critical health concerns (e.g., sexual health, emotional issues or community reintegration) are not addressed by family physicians or specialists.

There is level 5 evidence (from one observational study; (Guilcher et al., 2013) that emergency departments are often used as an improper substitute for primary care in individuals with SCI, particularly in rural areas, reflecting a lack of access to care for preventable conditions.

There is level 5 evidence (from four observational studies; (Donnelly et al., 2007; Jakimovska et al., 2017; Noreau et al., 2014; Stillman, Frost, Smalley, Bertocci, & Williams, 2014) that a significant proportion of individuals with SCI experience accessibility barriers during physician visits, do not receive routine screening or preventative testing and are not satisfied with the services received.

Hospital readmission occurs frequently for persons with SCI (particularly the first year post injury), with UTIs, pressure ulcers, respiratory infections and musculoskeletal problems among the most frequent causes.

Persons with SCI have more physician contacts than the general population, particularly the first year post injury.

Persons with chronic SCI are more likely to seek out family physicians than specialists; however, a significant proportion are not satisfied with the services received as accessibility barriers, lack of routine screening and critical health concerns are often not addressed.

A lack of access to care for preventable conditions often leads to emergency department visits as a substitute for primary care, particularly in rural areas.

8.3 Vocational Rehabilitation

Rates of employment after a SCI is low, with one systematic review reporting a global rate at 11.5% (Young & Murphy, 2009), with rates in the United States (Cao & Krause, 2020; L. Ottomanelli, Bradshaw, L. D., & Cipher, D. J., 2009; L. Ottomanelli, Goetz, Barnett, Njoh, & Fishalow, 2020) and Australia (Pat Dorsett & McLennan, 2019; Young & Murphy, 2009) at 35% and 30%, respectively. Of those that returned to work, most tend to be younger, obtained higher education or were previously employed in a middle-class occupation (Calliga & Porto, 2019; Leiulfsrud et al., 2020; L. Ottomanelli et al., 2020). In a small observational study, Ottomanelli et al. (2009) assessed veterans with SCI employment history, employment rate, awareness of vocational services, and utilization of vocational services. The majority of veterans were unaware of vocational services and awareness was significantly lower for persons with tetraplegia (95%) compared to paraplegia (80%) ($p<0.05$). Of the veterans aware of vocational services (20%), only 10% used them. Among those who did not return to work, 65.2% stated this was due to medical issues, followed by unsuccessful attempts at finding employment (13%), social barriers (8.7%), and not needing the income (8.7%). The findings of this study emphasize the need to educate veterans, especially those with more severe injuries, about vocational rehabilitation services as a possible means of improving employment outcomes in this special population.

Most vocational rehabilitation is conducted in the community, well after an individual endures a lengthy in-patient rehabilitation stay. Vocational programs have been shown to be effective. For example, in a review of employment outcomes among veterans with SCI, Ottomanelli et al. (2017) reported that a 24-month program of individual placement and supported employment resulted in an overall employment rate of 43.2%; further, participants averaged 38.2 weeks of employment. Although shown to be effective, in one study it was found that the majority of rehabilitation programs do not include vocational rehabilitation (Pat Dorsett & McLennan, 2019).

Studies have found that early intervention is one factor related to positive vocational outcomes, particularly when medical and vocational rehabilitation overlap (Langman 2011; Lukasczik et al. 2011). A qualitative study by Johnston et al. (D. Johnston et al., 2016) explored the perceptions of health professionals with respect to InVoc, an early vocational rehabilitation intervention provided to inpatients with SCI. To understand the program's most critical elements and whether it was successful, 25 allied staff participated in focus groups. Four main themes emerged: timeliness of the intervention, support and advocacy, value of early intervention, and conflicting messages to patients. Three critical program elements were identified: flexibility, coordinators working on the ward, and good communication between all staff. Overall, the early vocational rehabilitation program was perceived as appropriate and successfully implemented.

These findings were echoed in another qualitative study by Ramakrishnan et al. (Ramakrishnan et al., 2016) who performed semi-structured interviews with participants who completed an early-intervention vocational program. The program was viewed positively with emerging themes from participants suggesting it gave them a sense of direction and distraction, a feeling of advocacy and support, and "hope." This is supported by an observational study which found that participants who completed vocational rehabilitation experienced greater quality of life, albeit, no changes in depression (Calliga & Porto, 2019). Criticisms of the program were that it was offered too early in the intensive care unit when there were competing interests and information overload in the early recovery phase (Ramakrishnan et al., 2016).

Overall, vocational rehabilitation represents a small proportion of the scientific literature within SCI rehabilitation. A recent scoping review by Cotner et al. (Cotner, Ottomanelli, Keleher, & Dirk, 2019) collated the resources, tools, and educational materials available on vocational rehabilitation in SCI care. The authors reported that there are few resources to guide implementation of Individual Placement and Support (IPS); however, 16 essential resources were identified that, when combined, formed a toolkit. The toolkit, Tools for a Working Life: Individual Placement and Support in SCI Toolkit, could be used by all rehabilitation providers to educate individuals on effective ways of assisting people with SCI to find employment and transition into their placement. The toolkit is currently being field tested with clinical providers with an overall goal to adopt it into regular rehabilitation programs (Cotner et al., 2019).

Finally, Rapidi et al. (Rapidi et al., 2018) published a professional practice guide for physicians trained in the care of persons with SCI in the acute, subacute, and chronic phase of illness. A single recommendation was made with respect to vocational rehabilitation such that it should be "systematically and adequately offered to improve employment rates and decrease the high rates of unemployment of persons with SCI during their working life (pg. 803)."

9.0 Summary

There is level 3 evidence (from predominately American studies; (M. J. DeVivo et al., 1990; A. W. Heinemann et al., 1989; SA., 1999; G. Whiteneck et al., 2011; G. Whiteneck et al., 2012; Woolsey, 1985; Yarkony et al., 1987; Yarkony et al., 1990)) that rehabilitation LOS has become progressively shorter between 1973 and 2009. For other countries, only investigators from Israel (Ronen et al., 2004) have published data in a single report that is consistent with this trend.

There is level 3 evidence (based on several studies; (Chan & Chan, 2005; M. J. DeVivo et al., 1990; Tooth et al., 2003; G. Whiteneck et al., 2011; G. Whiteneck et al., 2012)) that those with higher level and more severe injuries have longer rehabilitation LOS.

There is level 4 evidence that a significant proportion of people (~50%) initially assessed as AIS B and C will improve by at least one AIS grade in the first few months post-injury concomitant with inpatient rehabilitation. Fewer individuals (~10%) initially assessed as AIS A and D will improve by one AIS grade.

There is level 4 evidence that individuals make significant functional gains during inpatient rehabilitation, more so for those with complete and incomplete paraplegia and incomplete tetraplegia.

There is level 4 (from one case series; (Allen W Heinemann et al., 1995) that increased therapeutic intensity may not be associated with functional benefit as measured by the Functional Independence Measure.

There is level conflicting level 5 evidence (from one observational study and one post-hoc analysis; (Kapadia et al., 2014; G. Whiteneck et al., 2012) that increased therapeutic intensity may be associated with increased functional benefit (as measured by the FIM and SCIM), independence, social integration, reduced hospitalizations and pressure ulcer incidence.

There is level 5 evidence (from one observational study; (G. Whiteneck et al., 2011) that treatment times and intensities vary extensively between patients and may be associated with length of stay, rather than patient, injury, or clinician characteristics.

There is level 3 evidence (from four case control studies; (Cifu, Huang, et al., 1999; Cifu, Seel, et al., 1999; Osterthun et al., 2009; Seel et al., 2001) that shorter rehabilitation LOS is associated with younger versus older individuals with paraplegia. The same may not be true for those with tetraplegia or for mixed cohorts involving traumatic and non-traumatic SCI.

There is level 3 evidence (from four case control studies; (M. J. DeVivo et al., 1990; Kennedy et al., 2003; G Scivoletto et al., 2003; Yarkony et al., 1988) and one observational

study (Marco Franceschini et al., 2020)) that age is inversely related to patient's independence level.

There is level 3 evidence (from five case control studies; (Cifu, Huang, et al., 1999; Cifu, Seel, et al., 1999; Kennedy et al., 2003; G Scivoletto et al., 2003; Seel et al., 2001) that younger as compared to older individuals are more likely to obtain greater functional benefits during rehabilitation.

There is level 3 evidence (from two case control studies; (Kennedy et al., 2003; G Scivoletto et al., 2003) that significant increases in neurological status during rehabilitation are more likely with younger than older individuals with tetraplegia or for mixed cohorts involving traumatic and non-traumatic SCI. The same may not be true for those with paraplegia.

There is conflicting level 3 evidence (from three case control studies; (Gupta et al., 2008; W. O. McKinley, Huang, et al., 1999; W. O. McKinley et al., 2002) that older individuals are more likely to experience a non-traumatic than traumatic SCI.

There is level 4 evidence (from one case series; (Tchvaloon et al., 2008) that older individuals are more at risk of developing pressure sores.

There is level 4 evidence (from two case series; (Anzai et al., 2006; Peter W New, 2005) that older individuals are more likely to be discharged to an extended care unit.

There is level 4 evidence (from one case series; (Eastwood et al., 1999) that age may be associated with longer length of rehabilitation stay.

There is level 4 and 5 evidence (from two case series and one observational study; (Furlan & Fehlings, 2009; Pollard & Apple, 2003; van der Putten et al., 2001) that younger patients are more likely to experience improved motor outcomes when compared to older individuals. However, both groups experience similar sensory deficits.

There is level 5 evidence (from one observational study; (Ronen et al., 2004) that age has no effect on length of acute hospital stay.

There is level 3 evidence (from five case control studies; (W. McKinley et al., 2008; W. O. McKinley, Huang, et al., 1999; W. O. McKinley et al., 2001; W. O. McKinley et al., 2002; Yokoyama et al., 2006) that those with non-traumatic SCI have generally reduced rehabilitation LOS and reduced hospital charges.

There is level 3 evidence (from one case control study; (Dionne et al., 2020)), level 4 evidence (from two case series; (Citterio et al., 2004; W. O. McKinley et al., 1996)) and level 5 evidence (from two observational studies; (Marco Franceschini et al., 2020; Halvorsen et al., 2019a) that those with non-traumatic SCI have similar discharge destinations as compared to those with traumatic SCI.

There is conflicting level 3 evidence (from seven case control studies; (Gupta et al., 2008; W. McKinley et al., 2008; W. O. McKinley et al., 2001; W. O. McKinley et al., 2002; Ones et al., 2007; Yokoyama et al., 2006) that individuals with non-traumatic SCI may experience

less functional gains than those with traumatic SCI, although many studies are comparing persons with different etiologies of non-traumatic SCI.

There is level 3 evidence (from one case control study; (Bradbury et al., 2008) that individuals with traumatic SCI with or without concomitant traumatic brain injury have similar LOS and achieve similar FIM motor scores, but associated costs were higher in those with dual diagnosis.

There is level 4 evidence (from one case series study; (van der Putten et al., 2001) that those with non-traumatic SCI are more likely to be older, female, have paraplegia and have an incomplete injury as compared to those with traumatic SCI.

There is conflicting level 4 evidence (from four case series; (Citterio et al., 2004; Gupta et al., 2009; W. O. McKinley et al., 1996; Peter W New, 2005) that patients with non-traumatic SCI recover significant neurological and functional improvements following rehabilitation.

There is conflicting level 3 (from three case control studies; (Greenwald et al., 2001; Ronen et al., 2004); Scivoletto, 2004 #64}, level 4 evidence (from four case studies; (Furlan et al., 2005; Peter W New, 2005; Pollard & Apple, 2003; Sipski et al., 2004) and level 5 evidence (from one observational study; (Marco Franceschini et al., 2020) that there is no difference with respect to gender on discharge destination, rehabilitation LOS and neurological or functional outcomes associated with rehabilitation.

There is conflicting level 3 (from four case control studies; (Gupta et al., 2008; W. McKinley et al., 2008; W. O. McKinley et al., 2002; Giorgio Scivoletto et al., 2004) and level 4 evidence (from one case series; (Sipski et al., 2004) that male patients experience more traumatic and incomplete injuries and of those that are female, younger females experience more complete injuries.

There is conflicting level 4 evidence (from one case series; (Furlan et al., 2005) that women may experience more complications at admission, psychiatric complications and deep vein thrombosis than men.

There is level 5 evidence (from one observational study; (J. S. Krause et al., 2006) that female patients utilize more non routine physician visits than males.

There is level 3 evidence (from one case control study; (Gupta et al., 2008) that socioeconomic status has no effect on type of injury.

There is level 5 evidence (from one observational study; (Chhabra & Bhalla, 2015) that financial constraints experienced by patients affect access to SCI care in all socioeconomic status groups, except those with the greatest socioeconomic status.

There is level 3 (from two case control studies and three case series; (Eastwood et al., 1999; J. S. Krause et al., 2006; Meade, Cifu, et al., 2004; Pollard & Apple, 2003; Putzke et al., 2002) that there is no difference with respect to race (Caucasians versus African-American) on rehabilitation LOS and neurological or functional outcomes associated

with rehabilitation that are not otherwise explained by socio-demographic or etiological differences.

There is level 3 evidence (from three case control studies; (A. W. Heinemann et al., 1989; Tator et al., 1995; Yarkony et al., 1985) that individuals cared for in interdisciplinary, specialist SCI acute care units soon after injury (most being admitted within 48 hours) begin their rehabilitation program earlier.

There is level 3 evidence (from one case control; (Donovan et al., 1984) and level 5 evidence (from one observational study; (Smith, 2002) that individuals cared for in interdisciplinary, specialist acute care SCI units have fewer complications upon entering and during their rehabilitation programs.

There is level 2 evidence (from two cohort studies; (McKechnie et al., 2019; Pattanakuhar et al., 2019)), level 3 evidence (from (A. W. Heinemann et al., 1989)) and level 4 evidence (from one pre-post test; (Chang et al., 2020) that individuals cared for in interdisciplinary, specialist SCI units make more efficient functional gains during rehabilitation (i.e., more or faster improvement).

There is level 3 evidence (from one case control study; (Tator et al., 1995) that individuals cared for in interdisciplinary, specialist SCI units have reduced mortality.

There is level 2 evidence (from one cohort study; (Cheng et al., 2017) that individuals who receive inpatient rehabilitation in specialist SCI rehabilitation units are more likely to be discharged home than those who do not.

There is level 3 evidence (based on several retrospective, case-control studies) that individuals admitted earlier to interdisciplinary, integrated specialist SCI units have a shorter total hospitalization length of stay than those admitted later.

There is level 3 evidence (based on several retrospective, case-control studies) that individuals admitted earlier to interdisciplinary, integrated specialist SCI units make greater functional gains in a shorter period of time (i.e., greater efficiency) than those admitted later.

There is level 3 evidence (based on several retrospective, case-control studies) that individuals admitted earlier to interdisciplinary, integrated specialist SCI units have fewer secondary medical complications (especially pressure sores) than those admitted later.

There is level 4 evidence (based on case series studies) for positive utility of admission to rehabilitation even at delays ≥90 days post injury.

Because of the variability between studies as to what constitutes "early" admission to interdisciplinary, specialist integrated SCI units, it is not possible to determine a specific period for optimal admission. At least one study has demonstrated benefits with an early admission described as ≤30 days post-injury. The majority of studies defined early admissions as 1-2 weeks post-injury, while studies focused on acute care describe early admission as within 24 hours post-injury.

There is Level 2 evidence (from a randomized controlled trial; Dallolio et al. (2008)) supported by level 4 evidence (from one prospective controlled trial; Phillips et al. (1999) and one pre-post test; Shem et al. (Shem et al., 2017)) that telerehabilitation is clinically feasible and may be an adjunct to routine follow-up care for a variety of secondary health complications, leading to improved patient satisfaction and enhance functional outcomes.

There is level 5 evidence (from one observational study; Kim et al. (2012)) that clinicians and individuals with SCI are interested in telerehabilitation, although, some concerns exist regarding the cost and risks (i.e., medical liability) of implementation.

There is limited level 4 evidence (from one prospective controlled trial; Dunn et al. (2000)) that provision of routine, comprehensive, specialist follow-up services may result in perceived improvements of health, independence and less feelings of depression.

There is limited level 4 evidence (from one prospective controlled trial; Bloemen-Vrencken et al. (2007)) that coordination of care through a community-based transmural nurse has no effect on reducing secondary complications and associated health utilization as compared to routine outpatient care consisting of periodic visits to a specialized rehabilitation doctor or centre.

There is level 4 evidence (from one pre-post test; Lugo et al. (2007)) that regular and accessible interdisciplinary follow-up can result in achieving functional goals where protocolized SCI care is unavailable.

There is level 4 evidence (from one pre-post test; Derakhshanrad et al. (2015)) that multidisciplinary outpatient rehabilitation programs may complement inpatient rehabilitation programs and promote functional recovery.

There is level 4 evidence (from one pre-post test; Zinman et al. (2014)) that there is a need for community reintegration programs following SCI, however, further research is necessary to determine the efficacy of such programs.

Across several studies there is level 2 evidence (from one cohort study; (Cai et al., 2020)), level 3 evidence (from one case control study; Dryden et al. 2004), level 4 evidence (from seven case series; (Charlifue et al., 2004; P. Dorsett & Geraghty, 2008; M. Franceschini et al., 2003; Jaglal et al., 2009; Middleton et al., 2004; Paker et al., 2006; Savic G, 2000) and level 5 evidence (from one observational study; (Cardenas et al., 2004)) that hospital readmission is a significant issue for individuals with SCI in all regions.

There is level 5 evidence (from two observational studies; (Cardenas et al., 2004; Charlifue et al., 2004) and level 4 evidence (from one case series; (Middleton et al., 2004) that hospital re-admission rates are highest in the first year post injury and then tend to decline in the first two years following injury.

There is level 4 evidence (from two case series; (P. Dorsett & Geraghty, 2008; Jaglal et al., 2009) that rehospitalization rates stabilize at a significantly high rate over time.

There is level 2 evidence (from four cohort studies; (Mashola et al., 2019; Ruediger et al., 2019; Sharwood et al., 2019; Skelton et al., 2019)), level 3 evidence (from one case control; (Dryden et al., 2004) supported by level 4 evidence (from 6 case series; (P. Dorsett & Geraghty, 2008; M. Franceschini et al., 2003; Jaglal et al., 2009; Middleton et al., 2004; Paker et al., 2006; Savic G, 2000) and level 5 evidence (from one observational study; (Cardenas et al., 2004) that urinary problems (UTIs), pressure ulcers, respiratory infections and musculoskeletal problems are consistently among the most frequent causes of emergency department visits and hospital readmissions in persons with SCI.

There is level 4 evidence (from three case series; (Charlifue et al., 2004; Jaglal et al., 2009; Middleton et al., 2004) and level 5 evidence (from two observational studies; (Cardenas et al., 2004; Sippel et al., 2019) that factors such as increased age, lower motor function, greater severity of injury, prior contact with the health system, rural habitation, mental health comorbidities and being unmarried are associated with a greater risk of hospital readmission.

There is level 3 evidence (from one case control study; (Guilcher et al., 2010) supported by level 5 evidence (from two observational studies; (Guilcher et al., 2013; Munce et al., 2009) that several factors are associated with a greater likelihood of physician visits including older age, lower FIM scores, discharge to chronic care or other rehabilitation facility, rural residence, comorbidities or in-hospital complications.

There is level 3 evidence (from one case control study; (Dryden et al., 2004) supported by level 5 evidence (from one observational study; (Amsters et al., 2014)) that persons with SCI have an increased number of physician contacts as compared to matched controls from the general population, especially in the first year post-injury.

There is level 5 evidence (from four observational studies; (Amsters et al., 2014; Donnelly et al., 2007; Munce et al., 2009; Noonan et al., 2017) that individuals with chronic SCI seek out family physicians rather than specialists, irrespective of country. However, many critical health concerns (e.g., sexual health, emotional issues or community reintegration) are not addressed by family physicians or specialists.

There is level 5 evidence (from one observational study; (Guilcher et al., 2013) that emergency departments are often used as an improper substitute for primary care in individuals with SCI, particularly in rural areas, reflecting a lack of access to care for preventable conditions.

There is level 5 evidence (from four observational studies; (Donnelly et al., 2007; Jakimovska et al., 2017; Noreau et al., 2014; Stillman et al., 2014) that a significant proportion of individuals with SCI experience accessibility barriers during physician visits, do not receive routine screening or preventative testing and are not satisfied with the services received.

10.0 References

Adams, R. D., & Salam-Adams, M. (1991). Chronic nontraumatic diseases of the spinal cord. *Neurol Clin, 9*(3), 605-623.

Al-Habib, A. F., Attabib, N., Ball, J., Bajammal, S., Casha, S., & Hurlbert, R. J. (2011). Clinical predictors of recovery after blunt spinal cord trauma: systematic review. *Journal of neurotrauma, 28*(8), 1431-1443.

Amin, A., Bernard, J., Nadarajah, R., Davies, N., Gow, F., & Tucker, S. (2005). Spinal injuries admitted to a specialist centre over a 5-year period: a study to evaluate delayed admission. *Spinal Cord, 43*(7), 434-437. doi:10.1038/sj.sc.3101734

Amsters, D., Schuurs, S., Kendall, M., Pershouse, K., Barker, R., & Kuipers, P. (2014). General practice visits by people with traumatic spinal cord injury: a Queensland longitudinal study. *Aust J Prim Health, 20*(2), 167-173. doi:10.1071/py12105

Anzai, K., Young, J., McCallum, J., Miller, B., & Jongbloed, L. (2006). Factors influencing discharge location following high lesion spinal cord injury rehabilitation in British Columbia, Canada. *Spinal Cord, 44*(1), 11-18. doi:10.1038/sj.sc.3101778

Aung, T. S., & el Masry, W. S. (1997). Audit of a British Centre for spinal injury. *Spinal Cord, 35*(3), 147-150. doi:10.1038/sj.sc.3100375

Barber, D. B., Woodard, F. L., Rogers, S. J., & Able, A. C. (1999). The efficacy of nursing education as an intervention in the treatment of recurrent urinary tract infections in individuals with spinal cord injury. *SCI Nurs, 16*(2), 54-56.

Bedbrook, G. (1979). Discerning matters of future importance in paraplegia. *Spinal Cord, 17*(1), 36-45.

Bedbrook, G. M., & Sedgley, G. I. (1980). The management of spinal injuries--past and present. *Int Rehabil Med, 2*(2), 45-61. doi:10.3109/09638288009163957

Bérard, É., Chougrani, M., & Tasseau, F. (2010). An evaluation of a post-acute rehabilitation unit after five years of operations. *Annals of physical and rehabilitation medicine, 53*(8), 457-473.

Blackwell, T. L., Krause, J. S., Winkler, T., & Stiens, S. A. (2001). *Spinal cord injury desk reference: guidelines for life care planning and case management*: Demos Medical Publishing.

Bloemen-Vrencken, J. H., de Witte, L. P., & Post, M. W. (2005). Follow-up care for persons with spinal cord injury living in the community: a systematic review of interventions and their evaluation. *Spinal Cord, 43*(8), 462-475. doi:10.1038/sj.sc.3101750

Bloemen-Vrencken, J. H., de Witte, L. P., Post, M. W., Pons, C., van Asbeck, F. W., van der Woude, L. H., & van den Heuvel, W. J. (2007). Comparison of two Dutch follow-up care models for spinal cord-injured patients and their impact on health problems, re-admissions and quality of care. *Clin Rehabil, 21*(11), 997-1006. doi:10.1177/0269215507079835

Bors, E. (1967). The Spinal Cord Injury Center of the Veterans Administration Hospital, Long Beach, California, USA. *Spinal Cord, 5*(3), 126-130.

Botticello, A. L., Chen, Y., Cao, Y., & Tulsky, D. S. (2011). Do communities matter after rehabilitation? The effect of socioeconomic and urban stratification on well-being after spinal cord injury. *Archives of physical medicine and rehabilitation, 92*(3), 464-471.

Botticello, A. L., Chen, Y., & Tulsky, D. S. (2012). Geographic variation in participation for physically disabled adults: the contribution of area economic factors to employment after spinal cord injury. *Soc Sci Med, 75*(8), 1505-1513. doi:10.1016/j.socscimed.2012.06.010

Bradbury, C. L., Wodchis, W. P., Mikulis, D. J., Pano, E. G., Hitzig, S. L., McGillivray, C. F., . . . Green, R. E. (2008). Traumatic brain injury in patients with traumatic spinal cord injury: clinical and economic consequences. *Archives of physical medicine and rehabilitation, 89*(12), S77-S84.

Brinkhof, M. W., Al-Khodairy, A., Eriks-Hoogland, I., Fekete, C., Hinrichs, T., Hund-Georgiadis, M., . . . Reinhardt, J. D. (2016). Health conditions in people with spinal cord injury: Contemporary evidence from a population-based community survey in Switzerland. *J Rehabil Med, 48*(2), 197-209. doi:10.2340/16501977-2039

Burke, D. C., Burley, H. T., & Ungar, G. H. (1985). Data on spinal injuries--Part II. Outcome of the treatment of 352 consecutive admissions. *Aust N Z J Surg, 55*(4), 377-382. doi:10.1111/j.1445-2197.1985.tb00904.x

Burns, A. S., Santos, A., Cheng, C. L., Chan, E., Fallah, N., Atkins, D., . . . Noonan, V. K. (2017). Understanding Length of Stay after Spinal Cord Injury: Insights and Limitations from the Access to Care and Timing Project. *J Neurotrauma, 34*(20), 2910-2916. doi:10.1089/neu.2016.4935

Cai, S., Bakerjian, D., Bang, H., Mahajan, S. M., Ota, D., & Kiratli, J. (2020). Data acquisition process for VA and non-VA emergency department and hospital utilization by veterans with spinal cord injury and disorders in California using VA and state data. *Journal of Spinal Cord Medicine*. doi:http://dx.doi.org/10.1080/10790268.2020.1773028

Calliga, M. C. N. D. S., & Porto, L. A. (2019). Which people with traumatic paraplegia return to work? *Quais pessoas com paraplegia traumatica voltam a trabalhar?, 24*(6), 2341-2350. doi:https://dx.doi.org/10.1590/1413-81232018246.15682017

Cao, Y., & Krause, J. S. (2020). Estimation of indirect costs based on employment and earnings changes after spinal cord injury: an observational study. *Spinal Cord, 58*(8), 908-913. doi:http://dx.doi.org/10.1038/s41393-020-0447-1

Cardenas, D. D., Hoffman, J. M., Kirshblum, S., & McKinley, W. (2004). Etiology and incidence of rehospitalization after traumatic spinal cord injury: a multicenter analysis. *Arch Phys Med Rehabil, 85*(11), 1757-1763. doi:10.1016/j.apmr.2004.03.016

Catz, A., Thaleisnik, M., Fishel, B., Ronen, J., Spasser, R., Folman, Y., . . . Gepstein, R. (2002). Recovery of neurologic function after spinal cord injury in Israel. *Spine (Phila Pa 1976), 27*(16), 1733-1735. doi:10.1097/00007632-200208150-00009

Celani, M. G., Spizzichino, L., Ricci, S., Zampolini, M., & Franceschini, M. (2001). Spinal cord injury in Italy: A multicenter retrospective study. *Arch Phys Med Rehabil, 82*(5), 589-596. doi:10.1053/apmr.2001.21948

Center, N. S. C. I. S. (2009). Annual Report for the Model SCI Care Systems. Retrieved from https://www.nscisc.uab.edu/public_content/annual_stat_report.aspx

Center., N. S. C. I. S. (2005). Annual Report for the Model SCI Care Systems. . Retrieved from https://www.nscisc.uab.edu/public_content/annual_stat_report.aspx. 2005; Last accessed: 10-4-0100.

Chan, S. C., & Chan, A. P. (2005). Rehabilitation outcomes following traumatic spinal cord injury in a tertiary spinal cord injury centre: a comparison with an international standard. *Spinal Cord, 43*(8), 489-498. doi:10.1038/sj.sc.3101743

Chang, F., Zhang, Q., Xie, H., Yang, Y., Sun, M., Wu, A., . . . Lu, J. (2020). Effects of a rehabilitation program for individuals with chronic spinal cord injury in Shanghai, China. *BMC health services research, 20*(1), 298. doi:http://dx.doi.org/10.1186/s12913-020-05181-x

Charlifue, S., Lammertse, D. P., & Adkins, R. H. (2004). Aging with spinal cord injury: changes in selected health indices and life satisfaction. *Arch Phys Med Rehabil, 85*(11), 1848-1853. doi:10.1016/j.apmr.2004.03.017

Cheng, C. L., Plashkes, T., Shen, T., Fallah, N., Humphreys, S., O'Connell, C., . . . Noonan, V. K. (2017). Does Specialized Inpatient Rehabilitation Affect Whether or Not People with Traumatic Spinal Cord Injury Return Home? *J Neurotrauma, 34*(20), 2867-2876. doi:10.1089/neu.2016.4930

Chhabra, H. S., & Bhalla, A. M. (2015). Influence of socio-economic status on access to different components of SCI management across Indian population. *Spinal Cord, 53*(11), 816-820. doi:10.1038/sc.2015.80

Cifu, D. X., Huang, M. E., Kolakowsky-Hayner, S. A., & Seel, R. T. (1999). Age, outcome, and rehabilitation costs after paraplegia caused by traumatic injury of the thoracic spinal cord, conus medullaris, and cauda equina. *J Neurotrauma, 16*(9), 805-815. doi:10.1089/neu.1999.16.805

Cifu, D. X., Seel, R. T., Kreutzer, J. S., & McKinley, W. O. (1999). A multicenter investigation of age-related differences in lengths of stay, hospitalization charges, and outcomes for a matched tetraplegia sample. *Arch Phys Med Rehabil, 80*(7), 733-740. doi:10.1016/s0003-9993(99)90219-8

Citterio, A., Franceschini, M., Spizzichino, L., Reggio, A., Rossi, B., & Stampacchia, G. (2004). Nontraumatic spinal cord injury: an Italian survey. *Arch Phys Med Rehabil, 85*(9), 1483-1487. doi:10.1016/j.apmr.2003.09.028

Cotner, B. A., Ottomanelli, L., Keleher, V., & Dirk, L. (2019). Scoping review of resources for integrating evidence-based supported employment into spinal cord injury rehabilitation. *Disabil Rehabil, 41*(14), 1719-1726. doi:10.1080/09638288.2018.1443161

Cox, R. J., Amsters, D. I., & Pershouse, K. J. (2001). The need for a multidisciplinary outreach service for people with spinal cord injury living in the community. *Clin Rehabil, 15*(6), 600-606. doi:10.1191/0269215501cr453oa

Dallolio, L., Menarini, M., China, S., Ventura, M., Stainthorpe, A., Soopramanien, A., . . . Fantini, M. P. (2008). Functional and clinical outcomes of telemedicine in patients with spinal cord injury. *Arch Phys Med Rehabil, 89*(12), 2332-2341. doi:10.1016/j.apmr.2008.06.012

Dalyan, M., Sherman, A., & Cardenas, D. (1998). Factors associated with contractures in acute spinal cord injury. *Spinal Cord, 36*(6), 405-408.

De Vivo, M. J., Richards, J. S., Stover, S. L., & Go, B. K. (1991). Spinal cord injury. Rehabilitation adds life to years. *West J Med, 154*(5), 602-606.

Derakhshanrad N, V. F., Yekaninejad MS, Moshayedi P, Saberi H (2015). Functional impact of multidisciplinary outpatient program on patients with chronic complete spinal cord injury. *Spinal Cord, 53*, 860-865.

DeVivo, M. (2007). Sir Ludwig Guttmann Lecture: trends in spinal cord injury rehabilitation outcomes from model systems in the United States: 1973–2006. *Spinal Cord, 45*(11), 713-721.

DeVivo, M. J., Kartus, P. L., Stover, S. L., & Fine, P. R. (1990). Benefits of early admission to an organised spinal cord injury care system. *Paraplegia, 28*(9), 545-555. doi:10.1038/sc.1990.74

DeVivo, M. J., La Verne, N. H., Richards, J. S., & Go, B. K. (1995). Outcomes of post-spinal cord injury marriages. *Archives of physical medicine and rehabilitation, 76*(2), 130-138.

Dinsdale, S., Thurber, D., Hough, E., & Rencz, S. (1981). Community based monitoring for spinal man. *Can J Public Health, 72*(3), 195-198.

Dionne, A., Richard-Denis, A., Lim, V., & Mac-Thiong, J. M. (2020). Factors associated with discharge destination following inpatient functional rehabilitation in patients with traumatic spinal cord injury. *Spinal Cord*. doi:http://dx.doi.org/10.1038/s41393-020-00542-z

Donnelly, C., McColl, M. A., Charlifue, S., Glass, C., O'Brien, P., Savic, G., & Smith, K. (2007). Utilization, access and satisfaction with primary care among people with spinal cord injuries: a comparison of three countries. *Spinal Cord, 45*(1), 25-36. doi:10.1038/sj.sc.3101933

Donovan, W. H., Carter, R. E., Bedbrook, G. M., Young, J. S., & Griffiths, E. R. (1984). Incidence of medical complications in spinal cord injury: patients in specialised, compared with non-specialised centres. *Spinal Cord, 22*(5), 282-290.

Dorsett, P., & Geraghty, T. (2008). Health-related outcomes of people with spinal cord injury--a 10 year longitudinal study. *Spinal Cord, 46*(5), 386-391. doi:10.1038/sj.sc.3102159

Dorsett, P., & McLennan, V. (2019). Exploring the 'status quo' in vocational rehabilitation and employment outcomes following spinal cord injury. *Journal of Vocational Rehabilitation, 50*(2), 131-139. doi:10.3233/JVR-180995

Dryden, D. M., Saunders, L. D., Rowe, B. H., May, L. A., Yiannakoulias, N., Svenson, L. W., . . . Voaklander, D. C. (2004). Utilization of health services following spinal cord injury: a 6-year follow-up study. *Spinal Cord, 42*(9), 513-525. doi:10.1038/sj.sc.3101629

Dunn, M., Love, L., & Ravesloot, C. (2000). Subjective health in spinal cord injury after outpatient healthcare follow-up. *Spinal Cord, 38*(2), 84-91. doi:10.1038/sj.sc.3100957

Eastwood, E. A., Hagglund, K. J., Ragnarsson, K. T., Gordon, W. A., & Marino, R. J. (1999). Medical rehabilitation length of stay and outcomes for persons with traumatic spinal cord injury--1990-1997. *Arch Phys Med Rehabil, 80*(11), 1457-1463. doi:10.1016/s0003-9993(99)90258-7

Ernst JL, T. L., Hahnstadt WA, Piskule AMA. . (1998). The Self-Identified Long-Term Care Needs of Persons with SCI. *SCI Psychosocial Process, 10*, 127-132.

Franceschini, M., Bonavita, J., Cecconi, L., Ferro, S., Pagliacci, M. C., for the Italian, S. C. I. S. G., . . . Falabella, V. (2020). Traumatic spinal cord injury in Italy 20 years later: current epidemiological trend and early predictors of rehabilitation outcome. *Spinal Cord, 58*(7), 768-777. doi:10.1038/s41393-020-0421-y

Franceschini, M., Di Clemente, B., Rampello, A., Nora, M., & Spizzichino, L. (2003). Longitudinal outcome 6 years after spinal cord injury. *Spinal Cord, 41*(5), 280-285. doi:10.1038/sj.sc.3101457

Furlan, J. C., & Fehlings, M. G. (2009). The impact of age on mortality, impairment, and disability among adults with acute traumatic spinal cord injury. *J Neurotrauma, 26*(10), 1707-1717. doi:10.1089/neu.2009-0888

10.1089/neu.2009.0888

Furlan, J. C., Krassioukov, A. V., & Fehlings, M. G. (2005). The effects of gender on clinical and neurological outcomes after acute cervical spinal cord injury. *J Neurotrauma, 22*(3), 368-381. doi:10.1089/neu.2005.22.368

Gassaway, J., Whiteneck, G., & Dijkers, M. (2009). Clinical taxonomy development and application in spinal cord injury research: the SCIRehab Project. *The journal of spinal cord medicine, 32*(3), 260-269.

Geisler, W. O., Jousse, A., Wynne-Jones, M., & Breithaupt, D. (1983). Survival in traumatic spinal cord injury. *Spinal Cord, 21*(6), 364-373.

Greenwald, B. D., Seel, R. T., Cifu, D. X., & Shah, A. N. (2001). Gender-related differences in acute rehabilitation lengths of stay, charges, and functional outcomes for a matched sample with spinal cord injury: a multicenter investigation. *Arch Phys Med Rehabil, 82*(9), 1181-1187. doi:10.1053/apmr.2001.24891

Guilcher, S. J., Craven, B. C., Calzavara, A., McColl, M. A., & Jaglal, S. B. (2013). Is the emergency department an appropriate substitute for primary care for persons with traumatic spinal cord injury? *Spinal Cord, 51*(3), 202-208. doi:10.1038/sc.2012.123

Guilcher, S. J., Munce, S. E., Couris, C. M., Fung, K., Craven, B. C., Verrier, M., & Jaglal, S. B. (2010). Health care utilization in non-traumatic and traumatic spinal cord injury: a population-based study. *Spinal Cord, 48*(1), 45-50. doi:10.1038/sc.2009.78

Gupta, A., Taly, A. B., Srivastava, A., & Murali, T. (2009). Non-traumatic spinal cord lesions: epidemiology, complications, neurological and functional outcome of rehabilitation. *Spinal Cord, 47*(4), 307-311. doi:10.1038/sc.2008.123

Gupta, A., Taly, A. B., Srivastava, A., Vishal, S., & Murali, T. (2008). Traumatic vs non-traumatic spinal cord lesions: comparison of neurological and functional outcome after in-patient rehabilitation. *Spinal Cord, 46*(7), 482-487. doi:10.1038/sj.sc.3102168

Guttmann, L. (1967). History of the national spinal injuries centre, Stoke Mandeville Hospital, Aylesbury. *Spinal Cord, 5*(3), 115-126.

Halvorsen, A., Pettersen, A. L., Nilsen, S. M., Halle, K. K., Schaanning, E. E., & Rekand, T. (2019a). Epidemiology of traumatic spinal cord injury in Norway in 2012-2016: a registry-based cross-sectional study. *Spinal Cord, 57*(4), 331-338. doi:http://dx.doi.org/10.1038/s41393-018-0225-5

Halvorsen, A., Pettersen, A. L., Nilsen, S. M., Halle, K. K., Schaanning, E. E., & Rekand, T. (2019b). Epidemiology of traumatic spinal cord injury in Norway in 2012–2016: a registry-based cross-sectional study. *Spinal Cord, 57*(4), 331-338. doi:10.1038/s41393-018-0225-5

Harvey, L., Lin, C.-W., Glinsky, J., & De Wolf, A. (2009). The effectiveness of physical interventions for people with spinal cord injuries: a systematic review. *Spinal Cord, 47*(3), 184-195.

Heinemann, A. W., Hamilton, B., Linacre, J. M., Wright, B. D., & Granger, C. (1995). Functional status and therapeutic intensity during inpatient rehabilitation. *American journal of physical medicine & rehabilitation, 74*(4), 315-326.

Heinemann, A. W., Linacre, J. M., Wright, B. D., Hamilton, B. B., & Granger, C. (1994). Prediction of rehabilitation outcomes with disability measures. *Archives of physical medicine and rehabilitation, 75*(2), 133-143.

Heinemann, A. W., Yarkony, G. M., Roth, E. J., Lovell, L., Hamilton, B., Ginsburg, K., . . . Meyer, P. R., Jr. (1989). Functional outcome following spinal cord injury. A comparison of specialized spinal cord injury center vs general hospital short-term care. *Arch Neurol, 46*(10), 1098-1102. doi:10.1001/archneur.1989.00520460084017

Jaglal, S. B., Munce, S. E., Guilcher, S. J., Couris, C. M., Fung, K., Craven, B. C., & Verrier, M. (2009). Health system factors associated with rehospitalizations after traumatic spinal cord injury: a population-based study. *Spinal Cord, 47*(8), 604-609. doi:10.1038/sc.2009.9

Jakimovska, V. M., Kostovski, E., Biering-Sorensen, F., & Lidal, I. B. (2017). Psychological distress and user experiences with health care provision in persons living with spinal cord injury for more than 20 years. *Spinal Cord, 55*(9), 864-869. doi:10.1038/sc.2017.29

James, M., DeVivo, M. J., & Richards, J. S. (1993). Postinjury employment outcomes among African-American and White persons with spinal cord injury. *Rehabilitation Psychology, 38*(3), 151.

Johnston, D., Ramakrishnan, K., Garth, B., Murphy, G., Middleton, J. W., & Cameron, I. D. (2016). Early access to vocational rehabilitation for inpatients with spinal cord injury: A qualitative study of staff perceptions. *J Rehabil Med, 48*(9), 776-780. doi:10.2340/16501977-2131

Johnston, M., & Miller, L. (1986). Cost-effectiveness of the Medicare three-hour regulation. *Archives of physical medicine and rehabilitation, 67*(9), 581-585.

Kapadia, N. M., Bagher, S., & Popovic, M. R. (2014). Influence of different rehabilitation therapy models on patient outcomes: Hand function therapy in individuals with incomplete SCI. *The journal of spinal cord medicine, 37*(6), 734-743.

Kennedy, P., Evans, M. J., Berry, C., & Mullin, J. (2003). Comparative analysis of goal achievement during rehabilitation for older and younger adults with spinal cord injury. *Spinal Cord, 41*(1), 44-52. doi:10.1038/sj.sc.3101386

Kim, J., Lim, S., Yun, J., & Kim, D. H. (2012). Telerehabilitation needs: a bidirectional survey of health professionals and individuals with spinal cord injury in South Korea. *Telemed J E Health, 18*(9), 713-717. doi:10.1089/tmj.2011.0275

Krause, J. S. (1998). Subjective well-being after spinal cord injury: Relationship to gender, race–ethnicity, and chronologic age. *Rehabilitation Psychology, 43*(4), 282.
Krause, J. S., Broderick, L. E., Saladin, L. K., & Broyles, J. (2006). Racial disparities in health outcomes after spinal cord injury: mediating effects of education and income. *J Spinal Cord Med, 29*(1), 17-25. doi:10.1080/10790268.2006.11753852
Krause, J. S., Sternberg, M., Maides, J., & Lottes, S. (1998). Employment after spinal cord injury: differences related to geographic region, gender, and race. *Archives of physical medicine and rehabilitation, 79*(6), 615-624.
Kurtzke, J. F. (1975). Epidemiology of spinal cord injury. *Experimental neurology, 48*(3), 163-236.
Le, C. T., & Price, M. (1982). Survival from spinal cord injury. *Journal of Clinical Epidemiology, 35*(6), 487-492.
Leiulfsrud, A. S., Solheim, E. F., Reinhardt, J. D., Post, M. W. M., Horsewell, J., Biering-Sorensen, F., & Leiulfsrud, H. (2020). Gender, class, employment status and social mobility following spinal cord injury in Denmark, the Netherlands, Norway and Switzerland. *Spinal Cord, 58*(2), 224-231. doi:http://dx.doi.org/10.1038/s41393-019-0356-3
Lugo, L. H., Salinas, F., & Garcia, H. I. (2007). Out-patient rehabilitation programme for spinal cord injured patients: evaluation of the results on motor FIM score. *Disabil Rehabil, 29*(11-12), 873-881. doi:10.1080/09638280701455494
Marino, R. J., Ditunno, J. F., Jr., Donovan, W. H., & Maynard, F., Jr. (1999). Neurologic recovery after traumatic spinal cord injury: data from the Model Spinal Cord Injury Systems. *Arch Phys Med Rehabil, 80*(11), 1391-1396. doi:10.1016/s0003-9993(99)90249-6
Martini, L., Maus, U., Bökel, A., Geng, V., Kalke, Y.-B., Liebscher, T., . . . Hoffmann, F. (2020). Utilization of Outpatient Physical and Occupational Therapy in People With Spinal Cord Injury in Germany: Results of the German Spinal Cord Injury Survey. *American journal of physical medicine & rehabilitation, 99*(6), 532-539. doi:10.1097/PHM.0000000000001366
Mashola, M. K., Olorunju, S. A. S., & Mothabeng, J. (2019). Factors related to hospital readmissions in people with spinal cord injury in South Africa. *South African Medical Journal, 109*(2), 107-111. doi:http://dx.doi.org/10.7196/SAMJ.2019.v109i2.13344
McKechnie, D., Pryor, J., Fisher, M. J., & Alexander, T. (2019). A comparison of patients managed in specialist versus non-specialist inpatient rehabilitation units in Australia. *Disabil Rehabil*, 1-8. doi:10.1080/09638288.2019.1568592
McKinley, W., Merrell, C., Meade, M., Brooke, K., & DiNicola, A. (2008). Rehabilitation outcomes after infection-related spinal cord disease: a retrospective analysis. *Am J Phys Med Rehabil, 87*(4), 275-280. doi:10.1097/PHM.0b013e318168cb6e
McKinley, W. O., Conti-Wyneken, A. R., Vokac, C. W., & Cifu, D. X. (1996). Rehabilitative functional outcome of patients with neoplastic spinal cord compressions. *Arch Phys Med Rehabil, 77*(9), 892-895. doi:10.1016/s0003-9993(96)90276-2
McKinley, W. O., Huang, M. E., & Brunsvold, K. T. (1999). Neoplastic versus traumatic spinal cord injury: an outcome comparison after inpatient rehabilitation. *Arch Phys Med Rehabil, 80*(10), 1253-1257. doi:10.1016/s0003-9993(99)90025-4
McKinley, W. O., Seel, R. T., Gadi, R. K., & Tewksbury, M. A. (2001). Nontraumatic vs. traumatic spinal cord injury: a rehabilitation outcome comparison. *American journal of physical medicine & rehabilitation, 80*(9), 693-699.
McKinley, W. O., Seel, R. T., & Hardman, J. T. (1999). Nontraumatic spinal cord injury: incidence, epidemiology, and functional outcome. *Arch Phys Med Rehabil, 80*(6), 619-623. doi:10.1016/s0003-9993(99)90162-4

McKinley, W. O., Tewksbury, M. A., & Mujteba, N. M. (2002). Spinal stenosis vs traumatic spinal cord injury: a rehabilitation outcome comparison. *The journal of spinal cord medicine, 25*(1), 28-32.

Meade, M. A., Cifu, D. X., Seel, R. T., McKinley, W. O., & Kreutzer, J. S. (2004). Medical procedures, complications, and outcomes for patients with spinal cord injury: A multicenter investigation comparing African Americans and whites. *Arch Phys Med Rehabil, 85*(3), 368-375. doi:10.1016/j.apmr.2003.06.008

Meade, M. A., Lewis, A., Jackson, M. N., & Hess, D. W. (2004). Race, employment, and spinal cord injury. *Arch Phys Med Rehabil, 85*(11), 1782-1792. doi:10.1016/j.apmr.2004.05.001

Middleton, J. W., Lim, K., Taylor, L., Soden, R., & Rutkowski, S. (2004). Patterns of morbidity and rehospitalisation following spinal cord injury. *Spinal Cord, 42*(6), 359-367. doi:10.1038/sj.sc.3101601

Moslavac, S., Dzidic, I., & Kejla, Z. (2008). Neurological outcome in road traffic accidents with spinal cord injury. *Coll Antropol, 32*(2), 583-586.

Munce, S. E., Guilcher, S. J., Couris, C. M., Fung, K., Craven, B. C., Verrier, M., & Jaglal, S. B. (2009). Physician utilization among adults with traumatic spinal cord injury in Ontario: a population-based study. *Spinal Cord, 47*(6), 470-476. doi:10.1038/sc.2008.173

Muslumanoglu, L., Aki, S., Ozturk, Y., Soy, D., Filiz, M., Karan, A., & Berker, E. (1997). Motor, sensory and functional recovery in patients with spinal cord lesions. *Spinal Cord, 35*(6), 386-389. doi:10.1038/sj.sc.3100406

Natale, A., Taylor, S., LaBarbera, J., Bensimon, L., McDowell, S., Mumma, S. L., . . . Gassaway, J. (2009). SCIRehab Project series: the physical therapy taxonomy. *The journal of spinal cord medicine, 32*(3), 270-282.

New, P. W. (2005). Functional outcomes and disability after nontraumatic spinal cord injury rehabilitation: results from a retrospective study. *Archives of physical medicine and rehabilitation, 86*(2), 250-261.

New, P. W. (2006). Non-traumatic spinal cord injury: what is the ideal setting for rehabilitation? *Aust Health Rev, 30*(3), 353-361. doi:10.1071/ah060353

New, P. W., Townson, A., Scivoletto, G., Post, M., Eriks-Hoogland, I., Gupta, A., . . . Gill, Z. (2013). International comparison of the organisation of rehabilitation services and systems of care for patients with spinal cord injury. *Spinal Cord, 51*(1), 33-39.

Noonan, V. K., Chan, E., Santos, A., Soril, L., Lewis, R., Singh, A., . . . Paquet, J. (2017). Traumatic spinal cord injury care in Canada: a survey of canadian centers. *Journal of neurotrauma, 34*(20), 2848-2855.

Noreau, L., Noonan, V. K., Cobb, J., Leblond, J., & Dumont, F. S. (2014). Spinal Cord Injury Community Survey: Understanding the Needs of Canadians with SCI. *Top Spinal Cord Inj Rehabil, 20*(4), 265-276. doi:10.1310/sci2004-265

Oakes, D. D., Wilmot, C. B., Hall, K. M., & Sherck, J. P. (1990). Benefits of early admission to a comprehensive trauma center for patients with spinal cord injury. *Arch Phys Med Rehabil, 71*(9), 637-643.

Ones, K., Yilmaz, E., Beydogan, A., Gultekin, O., & Caglar, N. (2007). Comparison of functional results in non-traumatic and traumatic spinal cord injury. *Disabil Rehabil, 29*(15), 1185-1191. doi:10.1080/09638280600902661

Osterthun, R., Post, M. W., & van Asbeck, F. W. (2009). Characteristics, length of stay and functional outcome of patients with spinal cord injury in Dutch and Flemish rehabilitation centres. *Spinal Cord, 47*(4), 339-344. doi:10.1038/sc.2008.127

Ottomanelli, L., Bradshaw, L. D., & Cipher, D. J. (2009). Employment and vocational rehabilitation services use among veterans with spinal cord injury. *Journal of Vocational Rehabilitation, 31*(1), 39-43.

Ottomanelli, L., Goetz, L. L., Barnett, S. D., Njoh, E., Dixon, T. M., Holmes, S. A., . . . White, K. T. (2017). Individual Placement and Support in Spinal Cord Injury: A Longitudinal

Observational Study of Employment Outcomes. *Arch Phys Med Rehabil, 98*(8), 1567-1575.e1561. doi:10.1016/j.apmr.2016.12.010
Ottomanelli, L., Goetz, L. L., Barnett, S. D., Njoh, E., & Fishalow, J. (2020). Factors associated with past and current employment of veterans with spinal cord injury. *Journal of Spinal Cord Medicine*, 1-11. doi:http://dx.doi.org/10.1080/10790268.2020.1769950
Ozelie, R., Sipple, C., Foy, T., Cantoni, K., Kellogg, K., Lookingbill, J., . . . Gassaway, J. (2009). SCIRehab Project series: the occupational therapy taxonomy. *The journal of spinal cord medicine, 32*(3), 283-297.
Pagliacci, M. C., Celani, M. G., Zampolini, M., Spizzichino, L., Franceschini, M., Baratta, S., . . . Perdon, L. (2003). An Italian survey of traumatic spinal cord injury. The Gruppo Italiano Studio Epidemiologico Mielolesioni study. *Arch Phys Med Rehabil, 84*(9), 1266-1275. doi:10.1016/s0003-9993(03)00234-x
Paker, N., Soy, D., Kesiktas, N., Nur Bardak, A., Erbil, M., Ersoy, S., & Ylmaz, H. (2006). Reasons for rehospitalization in patients with spinal cord injury: 5 years' experience. *Int J Rehabil Res, 29*(1), 71-76. doi:10.1097/01.mrr.0000185953.87304.2a
Pattanakuhar, S., Kammuang-lue, P., Kovindha, A., Komaratat, N., Mahachai, R., & Chotiyarnwong, C. (2019). Is admission to an SCI specialized rehabilitation facility associated with better functional outcomes? Analysis of data from the Thai Spinal Cord Injury Registry. *Spinal Cord, 57*(8), 684-691. doi:http://dx.doi.org/10.1038/s41393-019-0267-3
Phillips, V. L., Temkin, A., Vesmarovich, S., Burns, R., & Idleman, L. (1999). Using telehealth interventions to prevent pressure ulcers in newly injured spinal cord injury patients post-discharge. Results from a pilot study. *Int J Technol Assess Health Care, 15*(4), 749-755.
Phillips, V. L., Vesmarovich, S., Hauber, R., Wiggers, E., & Egner, A. (2001). Telehealth: reaching out to newly injured spinal cord patients. *Public Health Rep, 116 Suppl 1*, 94-102. doi:10.1093/phr/116.S1.94
Piatt, J. A., Nagata, S., Zahl, M., Li, J., & Rosenbluth, J. P. (2016). Problematic secondary health conditions among adults with spinal cord injury and its impact on social participation and daily life. *J Spinal Cord Med, 39*(6), 693-698. doi:10.1080/10790268.2015.1123845
Pickett, G. E., Campos-Benitez, M., Keller, J. L., & Duggal, N. (2006). Epidemiology of traumatic spinal cord injury in Canada. *Spine, 31*(7), 799-805.
Pollard, M. E., & Apple, D. F. (2003). Factors associated with improved neurologic outcomes in patients with incomplete tetraplegia. *Spine (Phila Pa 1976), 28*(1), 33-39. doi:10.1097/00007632-200301010-00009
Ponfick, M. (2017). Outcome after post-acute spinal cord specific rehabilitation: a German single center study. *Spinal Cord Ser Cases, 3*, 17055. doi:10.1038/scsandc.2017.55
Putzke, J. D., Hicken, B. L., & Richards, J. S. (2002). Race: predictor versus proxy variable? Outcomes after spinal cord injury. *Arch Phys Med Rehabil, 83*(11), 1603-1611. doi:10.1053/apmr.2002.35115
Ramakrishnan, K., Johnston, D., Garth, B., Murphy, G., Middleton, J., & Cameron, I. (2016). Early Access to Vocational Rehabilitation for Inpatients with Spinal Cord Injury: A Qualitative Study of Patients' Perceptions. *Top Spinal Cord Inj Rehabil, 22*(3), 183-191. doi:10.1310/sci2203-183
Rapidi, C.-A., Tederko, P., Moslavac, S., Popa, D., Branco, C. A., Kiekens, C., . . . Christodoulou, N. (2018). Evidence-based position paper on Physical and Rehabilitation Medicine (PRM) professional practice for persons with spinal cord injury. The European PRM position (UEMS PRM Section). *European journal of physical and rehabilitation medicine, 54*(5), 797-807.
Richardson, R. R., & Meyer, P. R. (1981). Prevalence and incidence of pressure sores in acute spinal cord injuries. *Spinal Cord, 19*(4), 235-247.

Ronca, E., Scheel-Sailer, A., Eriks-Hoogland, I., Brach, M., Debecker, I., & Gemperli, A. (2020). Factors influencing specialized health care utilization by individuals with spinal cord injury: a cross-sectional survey. *Spinal Cord*. doi:10.1038/s41393-020-00581-6

Ronen, J., Itzkovich, M., Bluvshtein, V., Thaleisnik, M., Goldin, D., Gelernter, I., . . . Catz, A. (2004). Length of stay in hospital following spinal cord lesions in Israel. *Spinal Cord, 42*(6), 353-358. doi:10.1038/sj.sc.3101590

Ruediger, M., Kupfer, M., & Leiby, B. E. (2019). Decreasing re-hospitalizations and emergency department visits in persons with recent spinal cord injuries using a specialized medical home. *Journal of Spinal Cord Medicine*. doi:10.1080/10790268.2019.1671075

SA., M. (1999). The Effect of Shorter Lengths of Stay on Functional Outcomes of Spinal Cord Injury Rehabilitation. . *Topics in Spinal Cord Injury Rehabilitation, 4*(4), 44-55.

Savic G, S. D., Weitzenkamp D, Charlifue S, Gardner BP. . (2000). Hospital readmissions in people with chronic spinal cord injury. . *Spinal Cord, 38*, 371-377.

Schonherr, M. C., Groothoff, J. W., Mulder, G. A., & Eisma, W. H. (1999). Functional outcome of patients with spinal cord injury: rehabilitation outcome study. *Clin Rehabil, 13*(6), 457-463. doi:10.1191/026921599666105472

Scivoletto, G., Marcella, M., Floriana, P., Federica, T., & Marco, M. (2020). Impact of complications at admission to rehabilitation on the functional status of patients with spinal cord lesion. *Spinal Cord, 58*(12), 1282-1290. doi:http://dx.doi.org/10.1038/s41393-020-0501-z

Scivoletto, G., Morganti, B., Cosentino, E., & Molinari, M. (2006). Utility of delayed spinal cord injury rehabilitation: an Italian study. *Neurol Sci, 27*(2), 86-90. doi:10.1007/s10072-006-0605-z

Scivoletto, G., Morganti, B., Ditunno, P., Ditunno, J., & Molinari, M. (2003). Effects on age on spinal cord lesion patients' rehabilitation. *Spinal Cord, 41*(8), 457-464.

Scivoletto, G., Morganti, B., & Molinari, M. (2004). Sex-related differences of rehabilitation outcomes of spinal cord lesion patients. *Clinical rehabilitation, 18*(6), 709-713.

Scivoletto, G., Morganti, B., & Molinari, M. (2005). Early versus delayed inpatient spinal cord injury rehabilitation: an Italian study. *Arch Phys Med Rehabil, 86*(3), 512-516. doi:10.1016/j.apmr.2004.05.021

Seel, R. T., Huang, M. E., Cifu, D. X., Kolakowsky-Hayner, S. A., & McKinley, W. O. (2001). Age-related differences in length of stays, hospitalization costs, and outcomes for an injury-matched sample of adults with paraplegia. *J Spinal Cord Med, 24*(4), 241-250. doi:10.1080/10790268.2001.11753581

Shackelford, M., Farley, T., & Vines, C. L. (1998). A comparison of women and men with spinal cord injury. *Spinal Cord, 36*(5), 337-339.

Sharwood, L. N., Moller, H., Young, J. T., Vaikuntam, B., Ivers, R. Q., Driscoll, T., & Middleton, J. W. (2019). The nature and cost of readmissions after work-related traumatic spinal injuries in New South Wales, Australia. *International Journal of Environmental Research and Public Health, 16*(9), 1509. doi:http://dx.doi.org/10.3390/ijerph16091509

Shem, K., Sechrist, S. J., Loomis, E., & Isaac, L. (2017). SCiPad: Effective Implementation of Telemedicine Using iPads with Individuals with Spinal Cord Injuries, a Case Series. *Front Med (Lausanne), 4*, 58. doi:10.3389/fmed.2017.00058

Sippel, J. L., Bozeman, S. M., Bradshaw, L., Cipher, D. J., McCarthy, M., & Wickremasinghe, I. M. (2019). Implementation and initial outcomes of a spinal cord injury home care program at a large veterans affairs medical center. *J Spinal Cord Med, 42*(2), 155-162. doi:10.1080/10790268.2018.1485311

Sipski, M. L., Jackson, A. B., Gomez-Marin, O., Estores, I., & Stein, A. (2004). Effects of gender on neurologic and functional recovery after spinal cord injury. *Arch Phys Med Rehabil, 85*(11), 1826-1836. doi:10.1016/j.apmr.2004.04.031

Skelton, F., Salemi, J. L., Akpati, L., Silva, S., Dongarwar, D., Trautner, B. W., & Salihu, H. M. (2019). Genitourinary Complications Are a Leading and Expensive Cause of Emergency Department and Inpatient Encounters for Persons With Spinal Cord Injury. *Archives of Physical Medicine and Rehabilitation, 100*(9), 1614-1621. doi:http://dx.doi.org/10.1016/j.apmr.2019.02.013

Smith, M. (2002). Efficacy of specialist versus non-specialist management of spinal cord injury within the UK. *Spinal Cord, 40*(1), 10-16. doi:10.1038/sj.sc.3101226

Statistics Canada. (2019). Population projections for Canada (2018 to 2068).

Stillman, M. D., Frost, K. L., Smalley, C., Bertocci, G., & Williams, S. (2014). Health care utilization and barriers experienced by individuals with spinal cord injury. *Arch Phys Med Rehabil, 95*(6), 1114-1126. doi:10.1016/j.apmr.2014.02.005

Stover, S. L. (1995). Review of forty years of rehabilitation issues in spinal cord injury. *J Spinal Cord Med, 18*(3), 175-182. doi:10.1080/10790268.1995.11719390

Stucki, G., Cieza, A., & Melvin, J. (2007). The international classification of functioning, disability and health: A unifying model for the conceptual description of the rehabilitation strategy. *Journal of rehabilitation medicine, 39*(4), 279-285.

Sumida, M., Fujimoto, M., Tokuhiro, A., Tominaga, T., Magara, A., & Uchida, R. (2001). Early rehabilitation effect for traumatic spinal cord injury. *Arch Phys Med Rehabil, 82*(3), 391-395. doi:10.1053/apmr.2001.19780

Tator, C., Duncan, E., Edmonds, V., Lapczak, L., & Andrews, D. (1995). Neurological recovery, mortality and length of stay after acute spinal cord injury associated with changes in management. *Spinal Cord, 33*(5), 254-262.

Tchvaloon, E., Front, L., Gelernter, I., Ronen, J., Bluvshtein, V., & Catz, A. (2008). Survival, neurological recovery and morbidity after spinal cord injuries following road accidents in Israel. *Spinal Cord, 46*(2), 145-149. doi:10.1038/sj.sc.3102086

Tooth, L., McKenna, K., & Geraghty, T. (2003). Rehabilitation outcomes in traumatic spinal cord injury in Australia: functional status, length of stay and discharge setting. *Spinal Cord, 41*(4), 220-230. doi:10.1038/sj.sc.3101433

Trezzini, B., Brach, M., Post, M., & Gemperli, A. (2019). Prevalence of and factors associated with expressed and unmet service needs reported by persons with spinal cord injury living in the community. *Spinal Cord, 57*(6), 490-500. doi:http://dx.doi.org/10.1038/s41393-019-0243-y

Truchon, C., Fallah, N., Santos, A., Vachon, J., Noonan, V. K., & Cheng, C. L. (2017). Impact of therapy on recovery during rehabilitation in patients with traumatic spinal cord injury. *Journal of neurotrauma, 34*(20), 2901-2909.

Ullrich, P. M., Lincoln, R. K., Tackett, M. J., Miskevics, S., Smith, B. M., & Weaver, F. M. (2013). Pain, depression, and health care utilization over time after spinal cord injury. *Rehabil Psychol, 58*(2), 158-165. doi:10.1037/a0032047

Vaidyanathan, S., Singh, G., Soni, B. M., Hughes, P. L., Mansour, P., Oo, T., . . . Sett, P. (2004). Do spinal cord injury patients always get the best treatment for neuropathic bladder after discharge from regional spinal injuries centre? *Spinal Cord, 42*(8), 438-442. doi:10.1038/sj.sc.3101576

van der Putten, J. J., Stevenson, V. L., Playford, E. D., & Thompson, A. J. (2001). Factors affecting functional outcome in patients with nontraumatic spinal cord lesions after inpatient rehabilitation. *Neurorehabil Neural Repair, 15*(2), 99-104. doi:10.1177/154596830101500203

Vesmarovich, S., Walker, T., Hauber, R. P., Temkin, A., & Burns, R. (1999). Use of telerehabilitation to manage pressure ulcers in persons with spinal cord injuries. *Adv Wound Care, 12*(5), 264-269.

Westgren, N., & Levi, R. (1994). Motherhood after traumatic spinal cord injury. *Spinal Cord, 32*(8), 517-523.

Whiteneck, G., Cassaway, J., Dijkers, M., & Jha, A. (2009). New approach to study the contents and outcomes of spinal cord injury rehabilitation: the SCIRehab Project. *The journal of spinal cord medicine, 32*(3), 251-259.
Whiteneck, G., Gassaway, J., Dijkers, M., Backus, D., Charlifue, S., Chen, D., . . . Smout, R. J. (2011). The SCIRehab project: treatment time spent in SCI rehabilitation. Inpatient treatment time across disciplines in spinal cord injury rehabilitation. *J Spinal Cord Med, 34*(2), 133-148. doi:10.1179/107902611x12971826988011
Whiteneck, G., Gassaway, J., Dijkers, M. P., Heinemann, A. W., & Kreider, S. E. (2012). Relationship of patient characteristics and rehabilitation services to outcomes following spinal cord injury: the SCIRehab project. *J Spinal Cord Med, 35*(6), 484-502. doi:10.1179/2045772312y.0000000057
Wilde, H., Gamblin, A. S., Reese, J., Garry, J. G., Guan, J., Mortenson, J., . . . Dailey, A. T. (2020). The Effect of Hospital Transfer on Patient Outcomes After Rehabilitation for Spinal Injury. *World Neurosurgery, 133*, e76-e83. doi:http://dx.doi.org/10.1016/j.wneu.2019.08.091
Wilson, C., Huston, T., Koval, J., Gordon, S. A., Schwebel, A., & Gassaway, J. (2009). SCIRehab Project series: the psychology taxonomy. *The journal of spinal cord medicine, 32*(3), 319-328.
Woolsey, R. M. (1985). Rehabilitation outcome following spinal cord injury. *Arch Neurol, 42*(2), 116-119. doi:10.1001/archneur.1985.04060020026008
World Health Organization. (1981). Disability prevention and rehabilitation–technical report series 668. *Geneva: WHO*, 1-40.
World Health Organization. (2001). *International classification of functioning, disability and health: ICF*: World Health Organization.
Yarkony, G. M., Bass, L. M., Keenan, V., 3rd, & Meyer, P. R., Jr. (1985). Contractures complicating spinal cord injury: incidence and comparison between spinal cord centre and general hospital acute care. *Paraplegia, 23*(5), 265-271. doi:10.1038/sc.1985.43
Yarkony, G. M., Roth, E. J., Heinemann, A. W., & Lovell, L. L. (1988). Spinal cord injury rehabilitation outcome: the impact of age. *J Clin Epidemiol, 41*(2), 173-177. doi:10.1016/0895-4356(88)90091-1
Yarkony, G. M., Roth, E. J., Heinemann, A. W., Wu, Y. C., Katz, R. T., & Lovell, L. (1987). Benefits of rehabilitation for traumatic spinal cord injury. Multivariate analysis in 711 patients. *Arch Neurol, 44*(1), 93-96. doi:10.1001/archneur.1987.00520130071020
Yarkony, G. M., Roth, E. J., Meyer, P. R., Jr., Lovell, L., Heinemann, A. W., & Betts, H. B. (1990). Spinal cord injury care system: fifteen-year experience at the Rehabilitation Institute of Chicago. *Paraplegia, 28*(5), 321-329. doi:10.1038/sc.1990.42
Yokoyama, O., Sakuma, F., Itoh, R., & Sashika, H. (2006). Paraplegia after aortic aneurysm repair versus traumatic spinal cord injury: functional outcome, complications, and therapy intensity of inpatient rehabilitation. *Arch Phys Med Rehabil, 87*(9), 1189-1194. doi:10.1016/j.apmr.2006.05.017
Young, A. E., & Murphy, G. C. (2009). Employment status after spinal cord injury (1992-2005): a review with implications for interpretation, evaluation, further research, and clinical practice. *Int J Rehabil Res, 32*(1), 1-11. doi:10.1097/MRR.0b013e32831c8b19
Zanca, J. M., Dijkers, M. P., Hammond, F. M., & Horn, S. D. (2013). Pain and its impact on inpatient rehabilitation for acute traumatic spinal cord injury: analysis of observational data collected in the SCIRehab study. *Arch Phys Med Rehabil, 94*(4 Suppl), S137-144. doi:10.1016/j.apmr.2012.10.035
Zhenrong, Z., Fangyong, W., & Yao, W. U. (2020). FACTORS AFFECTING LENGTH OF STAY IN HOSPITAL OF PATIENTS WITH TRAUMATIC SPINAL CORD INJURY IN CHINA. *Journal of Rehabilitation Medicine (Stiftelsen Rehabiliteringsinformation), 52*(11), 1-5. doi:10.2340/16501977-2761

Zinman, A., Digout, N., Bain, P., Haycock, S., Hebert, D., & Hitzig, S. L. (2014). Evaluation of a community reintegration outpatient program service for community-dwelling persons with spinal cord injury. *Rehabil Res Pract, 2014*, 989025. doi:10.1155/2014/989025

Abbreviations

AIS – ASIA Impairment Scale
ASIA – American Spinal Injury Association (and associated International Guidelines for Neurological Classification)
BI – Barthel Index
FIM – Functional Independence Measure
LOS – Length of Stay
MBI – Modified Barthel Index
OT – Occupational Therapy
SLT – Speech & Language Therapy
PT – Physical Therapy/Physiotherapy
UTI – Urinary Tract Infection