Key Points

Description of SCI Rehabilitation Outcomes

Rehabilitation Length of Stay

- Those with higher level and more severe injuries have longer rehabilitation LOS.
- Rehabilitation LOS in the US and Israel has become progressively shorter over the last few decades.

Neurological and Functional Status

- Most individuals make significant functional gains during inpatient rehabilitation.
- A significant proportion of people improve 1 AIS (ASIA Impairment Scale) grade in the first few months post-injury particularly those initially assessed AIS B and C.

Factors for Optimal Outcomes

Effect of Intensity on Rehabilitation Outcomes

- Increased therapeutic intensity may not necessarily lead to functional benefits, but data is scarce.

Effect of Age on Rehabilitation Outcomes

- Younger individuals with paraplegia are more likely to have shorter rehabilitation LOS than older individuals.
- Younger individuals are more likely to make greater functional gains during rehabilitation than older individuals.
- Younger individuals with tetraplegia (or in a mixed traumatic, nontraumatic sample) are more likely to make gains in neurological status during rehabilitation than older individuals.

Differences in Traumatic vs Non-Traumatic SCI Rehabilitation Outcomes

- Individuals with nontraumatic SCI have reduced LOS and less functional improvement with rehabilitation as compared to those with traumatic SCI, although additional studies that better control for nontraumatic subtypes are required.

Effect of Gender and Race on Rehabilitation Outcomes

- Neither gender nor race effects have been demonstrated for discharge destination, rehabilitation LOS and neurological or functional status in US Model Systems data.
Specialized vs General SCI Units (Acute Care)

- 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.

Early vs Delayed Admission to Specialized SCI Units

- 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.

Health Care After SCI Inpatient Rehabilitation

Outpatient and Follow-up Care

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

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

- Telehealth applications such as telemedicine may enhance patient satisfaction with follow-up services and also may improve functional outcomes.

Rehospitalization and Healthcare Utilization after Initial Rehabilitation in SCI

- Hospital readmission occurs frequently for persons with SCI (especially within 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, especially more so in the first year post-injury.
Table of Contents

1.0 Introduction .......................................................................................................................... 1
2.0 Common Abbreviations Used In SCI Rehabilitation ............................................................ 1
3.0 What is SCI Rehabilitation .................................................................................................. 2
4.0 Description of SCI Rehabilitation Outcomes ....................................................................... 3
   4.1 Rehabilitation Length of Stay .......................................................................................... 4
   4.2 Neurological and Functional Status ............................................................................... 9
5.0 Factors for Optimal Outcomes ............................................................................................ 14
   5.1 Effect of Intensity on Rehabilitation Outcomes .............................................................. 14
   5.2 Effect of Age on Rehabilitation Outcomes ..................................................................... 16
   5.3 Differences in Traumatic vs Non-Traumatic SCI Rehabilitation Outcomes ............... 22
   5.4 Effect of Gender and Race on Rehabilitation Outcomes ............................................... 30
6.0 Specialized vs General SCI Units (Acute Care) .................................................................. 36
7.0 Early vs Delayed Admission to Specialized SCI Units ......................................................... 40
8.0 Health Care After SCI Inpatient Rehabilitation .................................................................. 48
   8.1 Outpatient and Follow-up Care ..................................................................................... 48
   8.2 Rehospitalization and Healthcare Utilization after Initial Rehabilitation in SCI ............ 53
9.0 Summary ............................................................................................................................... 63
Appendix: Studies Describing Rehabilitation Outcomes ........................................................... 66
References .................................................................................................................................. 77

This review has been prepared based on the scientific and professional information available in 2009. The SCIRE information (print, CD or web site www.scireproject.com) is provided for informational and educational purposes only. If you have or suspect you have a health problem, you should consult your health care provider. The SCIRE editors, contributors and supporting partners shall not be liable for any damages, claims, liabilities, costs or obligations arising from the use or misuse of this material.


www.scireproject.com
Rehabilitation Practice And Associated Outcomes Following Spinal Cord Injury

1.0 Introduction

The 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 (Guttman 1967). Eventual adoption of this more specialized and integrated approach followed in many additional jurisdictions (Bors 1967; Bedbrook 1979), 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., UTI's, pressure sores, respiratory conditions) (Richardson & Meyer Jr. 1981; Le & Price 1982; Geisler et al. 1983).

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 et al. 1984; Tator et al. 1995). This is best facilitated under one roof or 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” more 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. Accordingly, when no specific intervention is assessed experimentally, a PEDro or Downs and Black (Downs & Black 1998) score is not provided. These articles were separated into five categories: Description of Rehabilitation Outcomes, Factors for Optimal Outcomes, Specialized vs. General SCI Units, Early vs. Delayed Admission to Specialized Units and Health Care After SCI Inpatient Rehabilitation.

In addition, in some studies the distinction between acute vs. rehabilitative care is somewhat blurred as studies may have been conducted in centers or systems where these services are more 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.

2.0 Common Abbreviations Used In SCI Rehabilitation

AIS – ASIA Impairment Scale

ASIA – American Spinal Injury Association (and associated International Guidelines for Neurological Classification)
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 directed towards persons with SCI has been likened to a “black box”, with research endeavours focused on the entire “rehabilitation package” but little emphasis on investigating the effectiveness of specific therapeutic practices (Whiteneck et al. 2009).

Although an internationally accepted definition of SCI rehabilitation and its essential elements remains to be determined, we have provided an operational definition that distinguishes between specialized and general programs of SCI rehabilitation on which this Chapter is based. This definition was informed by a preliminary review of service offerings among the 16 SCI US Model System rehabilitation programs (http://www.spinalcord.uab.edu/show.asp?durki=104757&site=1226&return=21392) and of Canadian SCI rehabilitation programs (SCISN Rehabilitation Escan; SCI Definitions Framework: http://www.gtarehabnetwork.ca/downloads/self-assessment-tool-sci-inpatient.pdf). In addition, other resources were reviewed 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 (Stucki et al. 2007) and SCI-specific rehabilitation (Harvey et al. 2009; DeVivo 2007; Blackwell et al. 2001). Given these resources, a definition of specialized SCI rehabilitation could be described as follows:

A specialized SCI rehabilitation program provides comprehensive, 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/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, the general rehabilitation program is 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 spinal cord injury 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 are currently efforts underway to “unravel” the “black box” of rehabilitation as applied to persons with SCI (Whiteneck et al. 2009). These investigators are employing a practice-based evidence approach across multiple centres to identify and investigate the myriad of practices that are conducted across the rehabilitation enterprise. They intend 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 that was required before embarking on this ambitious endeavour was to develop a taxonomy of rehabilitation interventions associated with every discipline contributing to SCI rehabilitation (Gassaway et al. 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 and occupational therapy, psychology, speech language pathology, therapeutic recreation, social work and nursing (e.g., Natale et al. 2009; Ozellie et al. 2009; Wilson et al. 2009; Gordon et al. 2009; Cahow et al. 2009; Abeytal et al. 2009; Johnson et al. 2009).

4.0 Description of SCI Rehabilitation Outcomes

Much research has been directed at describing outcomes following SCI rehabilitation and examining various factors that might be associated with good (or poor) 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 in this area in which large databases are mined for relationships among large arrays of variables, it is difficult to follow the same pattern of brevity and topic focus found in most chapters of the present review. In the present section we have taken a slightly different approach. First, a comprehensive table can be found in Section 9.0 Appendix 1 that lists specific studies in more detail and which outlines various findings directed at describing outcomes associated with comprehensive inpatient SCI rehabilitation.
This is intended as an overall resource for those interested in the specific findings relating to outcomes associated with rehabilitation practice. In the text are more focused tables summarizing specific data culled from the more comprehensive table (contained in the appendix), thereby permitting an assessment of similar types of rehabilitation outcomes. The subsequent section then describes more focused investigations that examine the effect of the various factors in producing optimal outcomes. These include studies that assess the effect of the intensity of rehabilitation, age, gender and race on rehabilitation outcomes.

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. Each of these measurement types comprise the topic areas of separate summary tables assembled from the more comprehensive table in Appendix 1. It should be noted that other measures of obvious importance to SCI rehabilitation care providers and people with SCI such as measures of health-related quality of life and those that assess different facets of community integration (e.g., employment status, Reintegration to Normal Living Index) have not been included in the present chapter as they are considered in the chapter entitled “Community Reintegration Issues Post Spinal Cord Injury”. In addition, studies examining health status have not been fully addressed in the present chapter as these typically report the incidence of specific secondary conditions (most notably, pressure sores and UTIs) and these will be described more fully in the specific chapters devoted to these issues.

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

<table>
<thead>
<tr>
<th>Outcome Measure Type</th>
<th>Specific Outcome Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Delivery Indicators</td>
<td>LOS, Hospital Charges, Discharge Destination</td>
</tr>
<tr>
<td>Functional Status</td>
<td>FIM, MBI</td>
</tr>
<tr>
<td>Neurological Status</td>
<td>AIS, ASIA motor scores, Frankel Index</td>
</tr>
<tr>
<td>Health Status</td>
<td>Incidence of secondary complications</td>
</tr>
</tbody>
</table>

It should also be noted that specific outcome measures can combine 2 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 length of stay (LOS) between countries or across other jurisdictions (Burke et al. 1985; Muslumanoglu et al. 1997; Pagliacci et al. 2003; Chan & Chan 2005). Additionally, others have noted the trend for progressively shorter LOS over the past several decades, especially in the US (De Vivo 2007; DeVivo et al. 1991; Morrison 1999; Eastwood et al. 1999) although there is also data from Israel that shows this as well (Ronen et al. 2004). Stover noted that reductions in the 1970s and early 1980s were likely due to increased efficiency of rehabilitation teams (Stover 1995). More recent reductions in the US have been attributed to restrictions imposed by payers (Morrison 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)**

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample Period</th>
<th>Length of Rehabilitation Stay (Days) (Mean unless otherwise stated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tooth et al. 2003</td>
<td>1993-1998</td>
<td>83.0 (Median)</td>
</tr>
<tr>
<td>Ronen et al. 2004</td>
<td>1962-1970, 1971-1980, 1981-1990, 1991-2000, 1996-2002</td>
<td>265±183&lt;sup&gt;1&lt;/sup&gt; 107±85&lt;sup&gt;2&lt;/sup&gt;, 210±137&lt;sup&gt;1&lt;/sup&gt; 124±90&lt;sup&gt;2&lt;/sup&gt;, 210±116&lt;sup&gt;1&lt;/sup&gt; 115±222&lt;sup&gt;2&lt;/sup&gt;, 231±108&lt;sup&gt;1&lt;/sup&gt; 91±81&lt;sup&gt;2&lt;/sup&gt;, 102±59&lt;sup&gt;1&lt;/sup&gt; 106±51&lt;sup&gt;2&lt;/sup&gt;&lt;br&gt;&lt;sup&gt;1&lt;/sup&gt;Trauma vs &lt;sup&gt;2&lt;/sup&gt;Nontrauma</td>
</tr>
<tr>
<td>Scivoletto et al. 2005</td>
<td>1997-2001</td>
<td>112.4±69.3</td>
</tr>
<tr>
<td>Scivoletto et al. 2003</td>
<td>1997-2001</td>
<td>98.7±68.13</td>
</tr>
<tr>
<td>Pagliacci et al. 2003</td>
<td>1997-1999</td>
<td>135.5</td>
</tr>
<tr>
<td>Sumida et al. 2001</td>
<td>1994-1997</td>
<td>185.6±130.4 (N=60)&lt;sup&gt;1&lt;/sup&gt;, 267.8±171.6 (N=63)&lt;sup&gt;2&lt;/sup&gt;&lt;br&gt;&lt;sup&gt;1&lt;/sup&gt;Early vs &lt;sup&gt;2&lt;/sup&gt;delayed admission</td>
</tr>
<tr>
<td>Study</td>
<td>Jurisdiction</td>
<td>Population N, Trauma &amp;/or Nontrauma</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Eastwood et al. 1999</td>
<td>USA (multi-centre)</td>
<td>3,904, Trauma</td>
</tr>
<tr>
<td>Morrison 1999</td>
<td>USA (single centre)</td>
<td>127, Trauma</td>
</tr>
<tr>
<td>Yarkony et al. 1990</td>
<td>USA (single centre)</td>
<td>1382, Trauma</td>
</tr>
<tr>
<td>Heinemann et al. 1989</td>
<td>USA (single centre)</td>
<td>338, unknown</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yarkony et al. 1987</td>
<td>USA (single centre)</td>
<td>711, Trauma</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 vs. tetraplegia) or completeness are shown in Table 3. Again 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)

<table>
<thead>
<tr>
<th>Study</th>
<th>Jurisdiction</th>
<th>Population N, Trauma &amp;/or Nontrauma</th>
<th>Sample Period</th>
<th>Length of Stay Result (Mean – in days) (±SD if available)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chan &amp; Chan 2005</td>
<td>China (Hong Kong)</td>
<td>33, Trauma</td>
<td>2002</td>
<td>• AIS D paraplegia – 79.42±20.07 (N=3)</td>
</tr>
<tr>
<td></td>
<td>(single centre)</td>
<td></td>
<td></td>
<td>• AIS ABC low paraplegia – 52.00±1.41 (N=2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• AIS ABC high paraplegia – 55.8±43.0 (N=2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• AIS D tetraplegia – 143.75±69.25 (N=4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• AIS ABC low tetraplegia – 215.9±56.1 (N=7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• AIS ABC high tetraplegia – 146.5±75.4 (N=6)</td>
</tr>
<tr>
<td>Study</td>
<td>Jurisdiction</td>
<td>Population</td>
<td>Sample Period</td>
<td>Length of Stay Result (Mean – in days) (±SD if available)</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------</td>
<td>------------------------</td>
<td>---------------------</td>
<td>----------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Ronen et al. 2004   | Israel       | 1367, Trauma & Nontrauma | 1962-2002           | • A 267±182<sup>1</sup> 231±128<sup>2</sup>  
• B 340±213<sup>1</sup> 153±108<sup>2</sup>  
• C 203±130<sup>1</sup> 112±77<sup>2</sup>  
• D 156±96<sup>1</sup> 73±183<sup>2</sup>  
<sup>1</sup>Trauma vs <sup>2</sup>Nontrauma |
| Tooth et al. 2003   | Australia    | 167, Trauma            | 1993-1998           | • Incomplete paraplegia – 43.0  
• Complete paraplegia – 96.5  
• Incomplete tetraplegia – 64.5  
• Complete tetraplegia – 206.0  
(Median) |
| Morrison 1999       | USA          | 127, Trauma            | 1995                | • Paraplegia - 46.7  
• Paraplegia - 82.2  
• Tetraplegia - 61.9  
• Tetraplegia - 110.9 |
| DeVivo et al. 1990  | USA          | 661, Trauma            | 1973-1985           | • Incomplete paraplegia – 46.3<sup>1</sup>, 50.6<sup>2</sup>  
• Complete paraplegia – 62.2<sup>1</sup>, 62.9<sup>2</sup>  
• Incomplete tetraplegia – 59.7<sup>1</sup>, 71.3<sup>2</sup>  
• Complete tetraplegia – 90.4<sup>1</sup>, 83.8<sup>2</sup>  
<sup>1</sup>Early (N=284) vs <sup>2</sup>later (N=377) admitted patients |
| Yarkony et al. 1990 | USA          | 1382, Trauma           | 1972-1986           | • Paraplegia – 54.3 (1986 data only)  
• Tetraplegia – 82.8 |
| Heinemann et al. 1989 | USA       | 338, unknown           | 1981-1985           | • Paraplegia – 68.7<sup>1</sup>, 70.7<sup>2</sup>  
• Tetraplegia – 98.0<sup>1</sup>, 103.4<sup>2</sup>  
<sup>1</sup>Specialist (N=185) vs <sup>2</sup>more general (N=153) care. |
| Yarkony et al. 1987 | USA          | 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          | 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 US has typically shorter rehabilitation LOS times than other countries reporting data. Most data has originated in the US, bolstered by the development of the US model systems database, with reports from other countries for the most part limited to a handful of descriptions of single-centre experience.
Within the US, it is clear that the trend for progressively shorter rehabilitation LOS has continued to 2009. Across 5 separate reports, the National SCI Statistical Centre (2005, 2009), DeVivo (2007), Morrison (1999) and Eastwood et al. (1999) indicated reduced LOS from the period between 1973 to 2006. Eastwood et al. (1999) examined the large US Model systems database of individuals with traumatic SCI (N=3,904) and reported annual mean LOS values from 1990 to 1997. 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 fairly stable at higher values, with 1994-1997 values lower and 1993 at an intermediate value. DeVivo (2007) has reported on the same dataset over a longer period of time beginning in 1973 (N=24,333), to extend the trend to a LOS of 45 days in 2006. Morrison (1999) performed a direct comparison of 1991 vs 1995 mean LOS values in the largest SCI rehabilitation in the US 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 US Model Systems databases (De Vivo et al. 1991). These same trends are apparent by looking at the public data available from the US National SCI Statistical Centre (NSCISC 2005, 2009).

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 (Tooth et al. 2003, Burke et al. 1985, Australia; Chan & Chan 2005, China; Pagliacci et al. 2003, Italy; Sumida et al. 2001, Japan; Schonherr et al. 1999, Netherlands) indicated LOS remains significantly longer than reported in US data. LOS data from these reports is displayed over time and across several countries in Figure 1 (Note: US Model Systems data for this figure is that reported in the National SCI Statistical Centre 2005 Annual Report).

A low-cost, low intensity, outpatient rehabilitation program is reported by a Columbian group (Lugo et al 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 of time 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 (De Vivo et al. 1990; Tooth et al. 2003; Chan & Chan 2005) 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 (with predominately US data) that rehabilitation LOS has become progressively shorter during the period of 1973 to 2006. For other countries, only investigators from Israel have published data in a single report that is consistent with this trend.*

*There is level 3 evidence that those with higher level and more severe injuries have longer rehabilitation LOS.*

\[
\text{LOS (Days)}
\]

![Graph showing Mean Rehabilitation Length of Stay Reported From Different Countries]

4.2 Neurological and Functional Status

Several studies have identified patterns of neurological and/or functional improvement over the first few months post-injury. The majority of these studies examine neurological and/or functional status and associated changes between rehabilitation admission and discharge. In
addition, the Consortium for Spinal Cord Medicine (1999) has published a review of expected neurological and functional outcomes following SCI. This Clinical Practice Guideline refers to the work of Bracken et al. (1993; 1997), Geisler et al. (1991) and Waters et al. (1994a; 1994b) in noting that over half of the expected recovery occurs in the first 2 months following injury and recovery may continue but slows noticeably after 3-6 months. This change in neurological status may represent the natural course of recovery, however, it is uncertain as to the extent that rehabilitation practices play in enhancing this recovery.

The Consortium for Spinal Cord Medicine (1999) Clinical Practice Guideline provides a comprehensive consensus review itemizing expected functional achievements for individuals at every level of SCI. Table 4 summarizes various reports in the literature for neurological and/or functional status organized by jurisdiction and also by the time period for which the data was collected. As above, 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).

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

<table>
<thead>
<tr>
<th>Study Jurisdiction N, Trauma &amp;/or Nontrauma</th>
<th>Outcome Measure and Sample Period</th>
<th>Neurological and/or Functional Change with Rehabilitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gupta et al. 2009</td>
<td>AIS</td>
<td>• AIS score showed significant neurological recovery during rehabilitation (p=0.001).</td>
</tr>
<tr>
<td>India (single centre) 64, Nontrauma</td>
<td>BI 2005-2008</td>
<td>• # 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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• BI scores showed significant functional recovery (p=0.000).</td>
</tr>
<tr>
<td>Moslavac et al. 2008</td>
<td>AIS</td>
<td>• 49% were AIS A at admission - of these, 93% remained an A at discharge, 5% to C and 1% to D.</td>
</tr>
<tr>
<td>Croatia (single centre) 154, Trauma</td>
<td>1991-2001</td>
<td>• 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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 21% were AIS C at admission – of these, 3% deteriorated to A, 9% remained C, 67% improved to D and 21% to E.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 12% were AIS D at admission – of these, 26% remained D and 74% improved to E.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 8% were AIS E at admission – all of these remained E.</td>
</tr>
<tr>
<td>DeVivo 2007 US multi-centre N=24,333</td>
<td>AIS</td>
<td>• 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.</td>
</tr>
<tr>
<td>Trauma</td>
<td>FIM 1973-2006</td>
<td>• Mean gain in FIM motor score decreased by 3.38 points during the past 20 years (p&lt;0.01) although FIM efficiency increased (p&lt;0.01) (discrepancy due to reduced LOS).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• FIM motor scores at admission &amp; discharge decreased significantly during the past 20 years (P&lt;0.0001).</td>
</tr>
<tr>
<td>Study Jurisdiction</td>
<td>Outcome Measure and Sample Period</td>
<td>Neurological and/or Functional Change with Rehabilitation</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Chan & Chan 2005 China (Hong Kong) (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). |
| 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 | FIM1993-1998 | - ↑ 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 | Frankel1962-1992 | - ↑ 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 | Frankel1989-1994 | - ↑ 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 nontraumatic SCI, 64% of those initially at C and 44% of those initially at B ↑. |
| Sumida et al. 2001 Japan (multi-centre) 123, Trauma & Nontrauma | AIS FIM1994-1997 | - Compared earlier vs 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 | AIS1988-1997 | - Increasingly greater likelihood of ↑ to D for initial AIS of C>>B>>A. |
- 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) vs no change 89% (A), 50.3% (B), 41.5% (C), 90.5% (D) vs 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). |
Study Jurisdiction N, Trauma &/or Nontrauma | Outcome Measure and Sample Period | Neurological and/or Functional Change with Rehabilitation
---|---|---
Yarkony et al. 1987 USA (single centre) 711, Trauma | MBI 1973-1980 | • ↑ in total scores & self-care and mobility subscores.  
• greater ↑ for incomplete vs complete and for those with paraplegia vs 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 (2007), Pagliacci et al. (2003), Celani et al. (2001), Marino et al. (1999) and DeVivo 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. (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 (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 2. This Figure 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; Marino et al. 1999; Sumida et al. 2001; Catz et al. 2002; Pagliacci et al. 2003; DeVivo 2007). 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. (2001) which included patients with SCI of both traumatic and nontraumatic etiology.

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, USA) with only 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 centers 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. (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.

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 (DeVivo et al. 1991; Muslumanoglu et al. 1997; Tooth et al. 2003; Chan & Chan 2005) 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 (De Vivo et al. 1991; Muslumanoglu et al. 1997; Tooth et al. 2003; Chan & Chan 2005). 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). 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 1 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 1 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 1 AIS (ASIA Impairment Scale) grade in the first few months post-injury, particularly those initially assessed AIS B and C.

5.0 Factors for Optimal Outcomes

5.1 Effect of Intensity on Rehabilitation Outcomes

Although it is commonly assumed that the therapies delivered during inpatient rehabilitation are effective, there is generally little direct evidence that demonstrates a clear relationship between typical therapeutic practice and enhanced functional outcomes (Heinemann et al. 1995). Moreover, there is no evidence that establishes a recommended intensity or amount of therapy that should be delivered to produce a desired result. In SCI rehabilitation, there exists a paucity of studies that examine this issue.

<table>
<thead>
<tr>
<th>Author Year</th>
<th>Country</th>
<th>Score</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heinemann et al. 1995 USA Down &amp; Black score=18 Prospective Controlled Initial N=264; Final N=246</td>
<td>Population: SCI and ABI, SCI: Mean age = 38.9 yrs; Gender: males = 79%, females = 21%. Treatment: Variation in therapy intensity (OT, PT, SLT, Psych). Also examined effect of various other factors including LOS, Interruptions, Onset days,</td>
<td>(SCI findings only) 1. When analysed together, none of the individual therapy intensities were predictive of improved outcomes. When analysed individually, very little was significant in the prediction with only greater</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Author Year Country Score Research Design Total Sample Size</td>
<td>Methods</td>
<td>Outcome</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
<td>---------</td>
<td>---------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admissions scores and age. <strong>Outcome Measures:</strong> FIM (motor, cognitive, total), FIM Efficiency (motor or cognitive) all collected at Discharge.</td>
<td>LOS associated with greater achievement of potential motor gains (p&lt;.05) and interrupted rehab associated with less achievement of potential motor gains (p&lt;.05). 2. Patients with &gt; 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&lt;.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 (psychology and all - p&lt;.001, speech &amp; OT - p&lt;.01, PT - p&lt;.05);</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: FIM=Functional Independence Measure; LOS=Length of stay*

**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, SLT 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.

**Conclusions**

*There is level 4 evidence based on a single case series that increased therapeutic intensity may not be associated with any functional benefit as measured by the FIM.*

Increased therapeutic intensity may not necessarily lead to functional benefits, but data is scarce.
5.2 Effect of Age on Rehabilitation Outcomes

Historically, traumatic SCI has been viewed as a young, male concern although there have been recent shifts in the demographics of SCI such that an increasing proportion of recently injured individuals are older (both male and female). In fact, recent epidemiological evidence from Ontario, Canada found that the highest rates of SCI-related hospital admission following trauma in this jurisdiction was for those over 70 years of age although the frequency of specific etiologies (e.g., falls vs motor vehicle crashes) varied with age (Pickett et al. 2006). In the US the average age at injury has increased steadily over the last 30 years with the US Model Systems National SCI Statistical Center (2006) reporting an average age of injury of 38.0 years for the period from 2000-2006 as compared to 28.7 years for the period from 1973-1979. In addition, many centers in various jurisdictions around the world also provide rehabilitation services to individuals with spinal cord damage as the result of a variety of nontraumatic etiologies and often these people are much older than those injured due to trauma (McKinley et al. 2001; McKinley et al. 2002; Scivoletto et al. 2003; New 2005).

Given these trends for increasing age in those undergoing rehabilitation it is important to understand the effects of age on rehabilitation outcomes. Several investigators have employed retrospective assessments of single or multi-centre patient databases to examine this issue (Cifu et al. 1999a; Cifu et al. 1999b; Seel et al. 2001; Scivoletto et al. 2003; Kennedy et al. 2003).

Table 6 Individual Studies – The Effect of Age on Rehabilitation Outcomes

<table>
<thead>
<tr>
<th>Author Year</th>
<th>Country</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kennedy et al. 2003</td>
<td>UK</td>
<td>Case Control (Inadequate control)</td>
<td>Initial N=200; Final N=192</td>
<td>Population: Traumatic and nontraumatic SCI: Mean age = 40.7 yrs; 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. Treatment: No treatment per se, but various outcomes associated with inpatient rehabilitation focusing on goal attainment in younger vs. older patients. Outcome Measures: Needs Assessment Checklist (NAC) collected within 2 weeks of mobilization and within 6 weeks of discharge.</td>
<td>1. Improvements were noted in ↓ &quot;percentage to be achieved&quot; scores for all 9 areas of need (p&lt;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&lt;0.005) and those with tetraplegia showed greater improvement in the area of skin care than those with paraplegia group (p&lt;0.005) Otherwise no other differences. 3. Mobility needs of older subjects were significantly higher compared to the younger subjects (p&lt;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 vs younger for the areas</td>
</tr>
<tr>
<td>Author Year Country</td>
<td>Research Design</td>
<td>Total Sample Size</td>
<td>Methods</td>
<td>Outcome</td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------</td>
<td>-------------------</td>
<td>---------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>Scivoletto et al. 2003 Italy Case Control</td>
<td>Initial N=284; Final N=284</td>
<td></td>
<td>Population: Mean age = 50.4 yrs; 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. Treatment: No treatment per se, but various outcomes associated with inpatient rehabilitation focusing on younger (&lt;50) vs older (&gt;50) patients. Mean LOS was 98.7±68.1 days.</td>
<td>1. Although LOS was longer for younger patients (111.3±63.88 vs 89±69.9, p&lt;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 (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&lt;0.001). 4. Younger age group had more people reach independent walking levels on WISCI than in older group (p&lt;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.</td>
<td></td>
</tr>
</tbody>
</table>

<p>| Seel et al. 2001 USA Case Control | Initial N=180; Final N=180 | | Population: Traumatic SCI from US Model Systems database: Gender: male, female, 3 equal (N=60) age groups (18-39, 40-59, &gt;59) matched for neurological level and ASIA classification, paraplegia, AIS A-D, 84% admitted within 21 days post-injury. Treatment: No treatment per se, but various outcomes associated with inpatient acute and rehabilitation care focusing on age effects by comparing results between 3 age categories. | 1. FIM improvement was greater for the younger and middle group that for the older group (p&lt;0.001). FIM efficiency was greater for the young group as compared to the 2 older groups (p&lt;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 |</p>
<table>
<thead>
<tr>
<th>Author Year</th>
<th>Country</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cifu et al. 1999a</td>
<td>USA</td>
<td>Case Control</td>
<td>Initial N=375; Final N=375</td>
<td>Charges, ASIA motor index score, Functional Independence Measure (FIM), change scores and efficiencies for FIM. All collected at admission to acute care and admission to rehabilitation care and discharge.</td>
<td>acute care LOS or hospital charges.</td>
</tr>
<tr>
<td>4. Rehabilitation LOS was significantly shorter for younger than middle or older groups. There was no difference in associated hospital charges for the 3 groups.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. All age groups were equally likely to be discharged to a private residence (≥92%).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population: Traumatic SCI from US Model Systems database: Gender: male and female, 3 equal (N=125) age groups (18-34, 35-64, &gt;64) matched for neurological level and completeness, tetraplegia, AIS A-D. 85% admitted within 21 days post-injury. Treatment: No treatment per se, but various outcomes associated with inpatient acute and rehabilitation care focusing on age effects by comparing results between 3 age categories. Outcome Measures: LOS, Charges, ASIA motor index score, Functional Independence Measure (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.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cifu et al. 1999b</td>
<td>USA</td>
<td>Case Control</td>
<td>Initial N=2,169; Final N=2,169</td>
<td>Charges, ASIA motor index score, Functional Independence Measure (FIM), change scores and efficiencies for FIM. All collected at admission to acute care and admission to rehabilitation care and discharge.</td>
<td>FIM improvement was less for people ≥ 60 than those younger.</td>
</tr>
<tr>
<td>2. There were no significant differences in ASIA motor index scores, change scores or efficiency scores across different ages.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. No systematic significant differences were noted for acute care LOS or hospital charges.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Rehabilitation LOS was longer and associated hospital charges greater for older individuals (trend beginning for those &gt; 54 and peaking in the 60-64 age group).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Younger age groups were</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population: Traumatic SCI from US Model Systems database: Mean age = 31.72 yrs; Gender: males = 83%, females = 17%; Level of injury: paraplegia; Severity of injury: AIS: A-D. Treatment: No treatment per se, but 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, Functional Independence Measure (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.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Author Year</td>
<td>Country</td>
<td>Research Design</td>
<td>Total Sample Size</td>
<td>Methods</td>
<td>Outcome</td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
<td>-----------------</td>
<td>-------------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>Devivo et al. 1990</td>
<td>USA</td>
<td>Case control</td>
<td>N=866</td>
<td>efficiencies for FIM and ASIA motor index. All collected at admission to acute care and admission to rehabilitation care and discharge.</td>
<td>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.</td>
</tr>
<tr>
<td>Yarkony et al. 1988</td>
<td>USA</td>
<td>Case control</td>
<td>N=866</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Population:** Group 1 (Age = 1-15yrs): Gender: males = 80%, females = 20%; Level of injury: paraplegia = 47.5%, tetraplegia 52.5%; Severity of injury: complete = 52.5%, incomplete = 47.5%; Group 2 (Age = 16-30yrs): Gender: males = 84.6%, females = 15.4%; Level of injury: paraplegia = 52.1%, tetraplegia 47.9%; Severity of injury: complete = 55%, incomplete = 45%;Group 3 (Age = 31-45yrs): Gender: males = 81.1%, females = 18.9%; Level of injury: paraplegia = 52%, tetraplegia 48%; Severity of injury: complete = 45.9%, incomplete = 54.1%; Group 4 (Age = 46-60yrs): Gender: males = 79%, females = 21%; Level of injury: paraplegia = 46%, tetraplegia 54%; Severity of injury: complete = 43%, incomplete = 57%; Group 5 (Age = 61-86yrs): Gender: males = 70%, females = 30%; Level of injury: paraplegia = 28.6%, tetraplegia 71.4%; Severity of injury: complete = 36.2%, incomplete = 63.8%.

**Treatment:** Patients were retrospectively divided into 5 age groups: Group 1 (1-15yrs), Group 2 (16-30yrs), Group 3 (31-45yrs), Group 4 (46-60yrs), Group 5 (61-86yrs). Data was then used to assess the effects of age on rehabilitation outcome.

**Outcome Measures:** Relationship of age with clinical outcomes.

1. Increase in age at admission was significantly related to increase in:
   - Cervical injuries with patients over 60 yrs 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=0.004).
   - 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).
<table>
<thead>
<tr>
<th>Author Year</th>
<th>Country</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tchvaloon et al. 2008</td>
<td>Israel</td>
<td>Case series</td>
<td>N=143</td>
<td>Population: Mean age=37.8yrs; Gender: M:F=4.95:1; Level of injury: C=43%, T=49.3%, L=7.7%; Severity of injury: complete=41%, incomplete=59%. Treatment: Data from patients with a SCI due to a road accident was analyzed.</td>
<td>1. Negative association was seen between survival and age at injury (p&lt;0.001) and pressure sores (p=0.006). 2. No significantly affect on recovery was seen due to age at injury, gender, presence of pressure sores and complications.</td>
</tr>
<tr>
<td>Anzai et al. 2006</td>
<td>Canada</td>
<td>Case series</td>
<td>N=52</td>
<td>Population: Mean age=45.3yrs; Gender: males=77%, females=23%; Level of injury: C4=63%; Severity of Injury: AIS A=60%. Treatment: Retrospective chart review was conducted on patients admitted to GF Strong Spinal Cord Program between 1994 and 2003.</td>
<td>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.</td>
</tr>
</tbody>
</table>

Note: AIS=ASIA Impairment Scale; ECU=Extended Care Unit; LOS=Length of stay; MBI=Modified Barthel Index;

**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 (i.e., Level 3) (Cifu et al. 1999b; Devivo et al. 1990; Seel et al. 2001; Scivoletto et al. 2003; Yarkony et al. 1988) as compared to those deemed as having an inadequate method of controlling for potential confounds (i.e., Level 4) (Cifu et al. 1999a; 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. (1999a) reported reduced rehabilitation LOS for those with paraplegia due to trauma whereas no differences were seen in investigations of those with tetraplegia due to trauma (Cifu et al. 1999b) and also with the mixed sample of people with both traumatic and nontraumatic SCI (Scivoletto et al. 2003).

Yarkony et al. (1988) was the first study to look at the independent effect of age on rehabilitation outcomes in SCI. This study found functional outcome was only related to age in patients with complete paraplegia. Within these individuals, Yarkony et al. (1988) demonstrated a trend between increase in age and increase 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 patient’s age and their level of independence in self-care activities. Anzai et al (2006) 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.

Conversely, all studies examining functional change showed that younger individuals demonstrated greater functional improvements as indicated by increases with the FIM (i.e., motor FIM scores, change scores, efficiencies) (Cifu et al. 1999a; Cifu et al. 1999b; Seel et al. 2001) or BI (Scivoletto et al. 2003). These similar results were obtained from studies involving those with paraplegia (Cifu et al. 1999a; Seel et al. 2001), tetraplegia (Cifu et al. 1999b) and a mixed sample comprised of those with both traumatic and nontrauma tic SCI (Scivoletto et al. 2003). On the other hand, Kennedy et al. (2003) employed the Needs Assessment Checklist (NAC) developed internally at Stoke-Mandeville, UK and demonstrated that there were few systematic age-related differences associated with goal attainment in a mixed traumatic, nontraumatic sample. The NAC 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 possessing measures of neurological status, both studies limited to those with paraplegia showed no age effects (Cifu et al. 1999a; Seel et al. 2001). Conversely, similar studies of those with tetraplegia or a mixed sample demonstrated that younger individuals were more likely to make significant neurological gains during inpatient rehabilitation (Cifu et al. 1999b; Scivoletto et al. 2003).

Conclusions

There is level 3 evidence that significantly shorter rehabilitation LOS is associated with younger vs older individuals with paraplegia. The same may not be true for those with tetraplegia or for mixed cohorts involving traumatic and nontraumatic SCI.

There is level 3 evidence that age is inversely related to patient’s independence level.

There is level 3 evidence that younger as compared to older individuals are more likely to obtain greater functional benefits during rehabilitation.

There is level 3 evidence 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 nontraumatic SCI. The same may not be true for those with paraplegia.

Younger individuals with paraplegia are more likely to have shorter rehabilitation LOS than older individuals.

Younger individuals are more likely to make greater functional gains during rehabilitation than older individuals.

Younger individuals with tetraplegia (or in a mixed traumatic, nontraumatic sample) are more likely to make gains in neurological status during rehabilitation than older individuals.

5.3 Differences in Traumatic vs Non-Traumatic SCI Rehabilitation Outcomes

Those individuals sustaining damage to the spinal cord due to nontraumatic 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 centers are associated with nontraumatic etiologies (Muslumanoglu et al. 1997; McKinley et al. 1999b; van der Putten et al. 2001). Despite these significant numbers, relatively little systematic research is directed at nontrauma tic SCI (van der Putten et al. 2001; McKinley et al. 2002). Common causes of nontraumatic 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; McKinley et al. 1999b; McKinley et al. 2001). Although estimates of the incidence of nontraumatic SCI have been provided (e.g., 8 per 100,000) (Kurtzke 1975), it is difficult to ensure accuracy given the heterogeneous nature of nontraumatic 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 nontraumatic vs. traumatic etiologies have demonstrated a variety of systematic differences between these 2 patient groups. In general, those with nontraumatic SCI are more likely to be older, female, have paraplegia and have an incomplete injury than those with traumatic SCI (McKinley et al. 1996; McKinley et al. 2001; McKinley et al. 2002; New 2005). In the present section, we review the studies characterizing rehabilitation outcomes between those with SCI due to nontraumatic vs traumatic causes.

Table 7 Individual Studies – Differences in Traumatic vs. Non-Traumatic SCI Rehabilitation Outcomes

<table>
<thead>
<tr>
<th>Author Year Country Score Research Design Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nontraumatic vs. Traumatic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Osterthun et al. 2009 Netherlands</td>
<td>Population: Traumatic SCI: Mean age=43.4yrs; Gender:</td>
<td>1. Functional status at admission and gain during rehabilitation</td>
</tr>
<tr>
<td>Year</td>
<td>Author</td>
<td>Country</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td>2008</td>
<td>McKinley et al.</td>
<td>USA</td>
</tr>
<tr>
<td>2007</td>
<td>Ones et al.</td>
<td>Turkey</td>
</tr>
<tr>
<td>2002</td>
<td>McKinley et al.</td>
<td>USA</td>
</tr>
</tbody>
</table>
**USA Case Control**  
*Initial N=381; Final N=183*

Secondary to stenosis (n=81) vs traumatic SCI (n=102) within a single centre; Matching from N=381 sample on paraplegia vs tetraplegia and completeness.  
**Treatment:** No treatment per se, but various outcomes associated with nontraumatic (stenosis) vs traumatic SCI rehabilitation.  
**Outcome Measures:** LOS, charges, Discharge rates to home, FIM (score, change and efficiency). Collected at admission to and discharge from rehabilitation.

**Population:** Nontraumatic SCI (n=87) from a single centre vs traumatic SCI (n=107) from the US Model Systems database; Matched on level and completeness of lesion and age; 2/3rd 30-59 years, 1/3rd 60+ years; 93% were admitted within 21 days of injury; 68% were paraplegic; AIS C 36%, AIS D 41%.  
**Treatment:** No treatment per se, outcomes associated with nontraumatic vs traumatic rehabilitation.  
**Outcome Measures:** LOS, charges, motor FIM (score, change and efficiency). Collected at admission to and discharge from rehabilitation.

1. As compared to those with trauma (after matching), those with nontrauma had significantly (p<0.05) …  
   • Older (64.1 vs 44.4).  
   • More likely female (38.8 vs 21.2%)  
   • More likely to have paraplegia (69.4% vs 45.5%)  
   • More likely to be incomplete injury (AIS C or D) (100% vs 49.3%)  
2. As compared to those with trauma (after matching), those with nontrauma SCI had …  
   1.↓ rehabilitation LOS (22.46 vs 41.49 days) (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 FIM totals  
   6. no difference in discharge destination.

**McKinley et al. 2001**  
*USA Case Control*  
*Initial N=174; Final N=174*

**Population:** Traumatic (n=38): Mean age = 32.86yrs; Gender: males = 34, females = 4; Nontraumatic (n=38): Mean age = 31.10; Gender: males = 16, females = 22  
**Treatment:** Admission / discharge data from all surviving nontraumatic and traumatic spinal cord lesion (SCL) patients in a neurological rehabilitation facility was assessed over a 2 year 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.  
2. LOS was 66.0±47.7 days (trauma) and 60.7±45.7 which was not significantly different between groups.  
3. Both trauma and nontrauma patients showed significant gains in function with BI increasing significantly from admission to discharge (p<0.05) although there was no
### McKinley et al. 1999
**USA**  
**Case Control**  
**Initial N = 4,035; Final N=58**

| **Population:** Nontraumatic SCI secondary to neoplastic cord compression admitted over 5 years (within a single centre (n=29) vs traumatic SCI (n=29)) from the US Model Systems database matched by age, level of injury and AIS; Age = 57.8 years; AIS A-D; C4-L2.  
**Treatment:** No treatment per se, but various outcomes associated with rehabilitation care of nontraumatic (neoplastic cord compression) vs traumatic SCI.  
**Outcome Measures:** LOS, Discharge destination, FIM (total score, change and efficiency). Collected at admission to and discharge from rehabilitation. |
|---|
| 1. As compared to those with trauma (before matching), those with neoplastic cord compression were …  
- older (57.8 vs 30.45).  
- more likely to have paraplegia (88.2% vs 52.5%)  
- more likely to be incomplete (88.2% vs 56.7%)  
2. As compared to those with trauma (after matching), those with neoplastic cord compression …  
- had ↓ LOS (25.17 vs 57.46 days)  
- had ↓ motor FIM change  
- had ↓ motor FIM scores at discharge  
- no different FIM efficiency  
- no different for discharge destination. |

### Bradbury et al. 2008
**Canada**  
**Case control**  
**N=20**

| **Population:** SCI/TBI: Mean age=35.9yrs; Gender: males = 7, females =3; Level of injury: C =6, L =1, T=3; Severity of injury: complete = 3, incomplete = 7; SCI: Mean age=36.3yrs; Gender: males =7, females =3; Level of injury: C=6, L=1, T=3; Severity of injury: complete = 3, incomplete = 7.  
**Treatment:** Rehabilitation data was analyzed of patients with SCI and TBI 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 vs. $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). |

### Yokoyama et al. 2006
**Japan**  
**Case control**  
**N=34**

| **Population:** SCI due to aortic aneurysm: Mean age=58.6yrs; Level of injury: T=17; Severity of injury: AIS A=8, B=2, C=3, D=4; Traumatic SCI: Mean age=57.2yrs; Level of injury: T=17; Severity of injury: AIS A=8, B=2, C=3, D=4  
**Treatment:** 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 undergone a rehabilitation program |
|---|
| 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 |
consisting of 40 mins of physical therapy, 40 minutes of occupational therapy and 40 minutes of rehabilitation sports therapy per day for 5 days a week. **Outcome Measures:** FIM, LOS, discharge, complications

**Outcome Measures:** 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).

6. 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.

<table>
<thead>
<tr>
<th>Non-Traumatic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Population:</strong> Nontraumatic SCI: Mean age = 55 yrs; Level of injury: cervical = 72, thorocolumbar = 251; Severity of injury: complete = 79, incomplete = 244; Etiology of injury: inflammatory = 63, vascular = 81, neoplastic = 81, degenerative = 60, other = 38. <strong>Treatment:</strong> Patients with nontraumatic SCI involved in rehabilitation were recruited and clinical data was analyzed. <strong>Outcome Measures:</strong> LOS, AIS grade, complications, discharge destination.</td>
</tr>
</tbody>
</table>
| **Citterio et al. 2004**  
 **Italy**  
 **Case series**  
 **N=323** |
| 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 center 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**  
 **Initial N=100; Final N=100** |
| **Population:** Nontraumatic SCI: mean age=55 years (16-88); 54% male; cervical 49%, upper thoracic 21%, lower thoracic and lumbar 22%; Time from onset to rehabilitation=4.8 years (0.1-32 years). **Treatment:** No treatment per se, but optimal outcomes were regressed against various factors associated with nontraumatic |
| 1. LOS = 31.5 days (9-184 days).  
 2. FIM motor score was associated with lower score on admission and reduced time between 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 |
<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Study Design</th>
<th>Initial N</th>
<th>Final N</th>
<th>Population</th>
<th>Treatment</th>
<th>Outcome Measures</th>
<th>Results</th>
</tr>
</thead>
</table>
| Gupta et al. 2009 | India | Observational | N=64 | | Mean age = 30.64; Gender: males = 28, females = 36; Level of injury: paraplegia =67.2%; quadriplegia = 32.8%; Duration of illness =7.1±9.2 months. | No treatment per se, outcomes associated with neurological rehabilitation from June 2005 to January 2008 was analyzed. | Functional (BI) and neurological (AIS) outcomes and complication prevalence collected at admission and discharge. | - LOS was 55.8±40.9 days (Range 14-193 days).  
1. BI scores showed significant functional recovery (p=0.000).  
2. AIS score showed significant neurological recovery during rehabilitation (p=0.001).  
3. # 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.  
4. 90% of patients reported at least one complication during rehabilitation.  
5. Most common medical complications were urinary tract infection (50.0%), spasticity (35.9%), urinary incontinence (31.3%) and pressure ulcer (25.0%). |
| New et al. 2005 | Australia | Case Series | Initial N=70; Final N=62 | | Nontraumatic SCI: Mean age = 69 yrs; AIS B-D tetraplegia 32.9%, AIS A paraplegia=8.6%, AIS B-D= 58/6%; 78.6% had relatively fast onset (<7 days) and were admitted to rehabilitation=30.9 days, 21.4% had gradual onset and were admitted=11.0 months. | No treatment per se, outcomes associated with nontraumatic SCI rehabilitation. | 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. | - LOS =55.8 days (7-413 days).  
1. FIM motor scores during rehabilitation from 40.8 to 67.1, cognitive FIM showed no change due to initial ceiling effect.  
2. 17.7% overall and 26.9% over the age of 70 were discharged to a nursing home.  
3. Those subjects male, younger, more mobile, more independent bowel and bladder function and less severe AIS grades were more likely to be discharged home.  
4. Major nontrauma classifications were tumour (32.9%), degenerative (25.7%), vascular (14.3%) and other (27.1%). |
| McKinley et al. 1996 | USA | Case Series | Initial N=32; Final N=20 | | Nontraumatic SCI secondary to neoplastic cord compression admitted over 5 years within a single centre; Mean age=64 years; 18 men, 14 women. | No treatment per se, but outcomes associated with rehabilitation care. | Medical complications, AIS, LOS, bladder function, FIM, Discharge destination. All collected at admission to and discharge from rehabilitation. Level of ambulation | - LOS = 27 days (7-54 days).  
1. People showed significant! in 9 FIM categories (0<0.005) associated with mobility and self-care during rehabilitation.  
2. 11 individuals improved from AIS C to D at discharge.  
3. 27/32 were discharged home, 4 transferred for medical reasons (and died within 2 months) and 1 died before discharge.  
4. Of 20 people with assessed at 3-15 month follow-up, 16 had |
and dressing ability assessed at 3-15 months post-discharge. maintained mobility and dressing function as compared to discharge. However, 12/20 had eventually died at a mean of 101 days post-discharge.

Note: AIS=ASIA Impairment Scale; BI=Barthel Index; FIM=Functional Independence Measure; LOS=Length of Stay; UTI=Urinary Tract Infection

Discussion

Studies examining nontraumatic SCI typically make use of retrospective case series designs describing rehabilitation outcomes directly (Citterio et al. 2004; McKinley et al. 1996; van der Putten et al. 2001; New et al. 2005; New 2006) 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 (McKinley et al. 1999; McKinley et al. 2001; McKinley et al. 2002, 2008). As noted above, those with nontraumatic SCI were more likely to be older, female, have paraplegia and have an incomplete injury than those with traumatic SCI (McKinley et al. 1996; McKinley et al. 2001; McKinley et al. 2002; New 2005). No difference in age, marriage, education, socioeconomic factors, LoS and functional outcome was reported for a case control analysis originating from India (Gupta et al 2008, N=76)

Patients with nontraumatic SCI were primarily discharged home after rehabilitation (Citterio et al. 2004; McKinley et al. 1996). 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.

Ones et al. (2007) and Yokoyama et al. (2006) showed no significant difference in LOS between individuals with traumatic vs. nontraumatic spinal cord injury. Conversely, when direct comparisons of traumatic and nontraumatic SCI of various etiologies have been conducted using matching procedures, it is clear that shorter rehabilitation LOS was seen for those with nontraumatic SCI (McKinley et al. 2001; Osterthum et al 2009). In addition, this shorter LOS was associated with reduced hospital charges for both an overall and a per diem basis (McKinley et al. 2001). These findings were replicated with similar studies examining subsets of those with nontraumatic SCI including those with stenosis (McKinley et al. 2002) and those with neoplastic cord compression (McKinley et al. 1999) although this was not the case for a review involving infection-based SCI (McKinley et al. 2008). Most of these findings have been established with data from the US Model Systems, although at least two reports from other jurisdictions have reported longer rehabilitation LOS (van der Putten et al. 2001; New 2005).

None of the studies employing matching procedures noted differences in discharge destinations for those with nontraumatic SCI as compared to those with traumatic SCI (McKinley et al. 1999; McKinley et al. 2001; McKinley et al. 2002). although New et al. (2005) did note that within nontraumatic subjects, those individuals 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 (McKinley et al. 1996) although no specific differences were noted in a matched comparison (McKinley 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 clinical 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 (McKinley et al. 1999; New 2005). There was conflicting evidence in admission and discharge FIM scores between traumatic and nontraumatic SCI groups. A study by Ones et al. (2007) found patients with traumatic SCI had significantly lower admission FIM scores than those with nontraumatic SCI. However, other studies found no such trend (McKinley et al. 1999; McKinley et al. 2001). FIM discharge scores were shown to be lower in the nontraumatic SCI population than traumatic (McKinley et al. 1999; McKinley et al. 2001) while Ones et al. (2007) showed no such difference. When examining only those with stenosis vs those with traumatic SCI, those with nontraumatic SCI had higher FIM scores on admission, similar scores on discharge, resulting in reduced change scores and lower efficiency (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 (McKinley et al. 1999).

McKinley et al. (1999) and McKinley et al. (2001) found no significant difference between traumatic vs. nontraumatic 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 nontraumatic 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 nontraumatic etiologies. In particular, much variation might be expected, especially between centre-based reports with relatively small sample sizes and which include various nontraumatic etiologies within a single nontraumatic 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 nontraumatic 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 nontraumatic SCI with rehabilitation periods of > 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.

**Conclusions**

There is level 4 evidence that those with nontraumatic SCI are more likely to be older, female, have paraplegia and have an incomplete injury as compared to those with traumatic SCI.

There is level 3 evidence that those with nontraumatic SCI have generally reduced rehabilitation LOS, reduced hospital charges but similar discharge destinations as compared to those with traumatic SCI.
There is conflicting level 3 evidence that individuals with nontraumatic SCI have lower FIM efficiencies than those with traumatic SCI, although many studies are comparing persons with different etiologies of nontraumatic SCI.

There is level 3 evidence that individuals with traumatic SCI with or without concomitant TBI have similar LoS and achieve similar FIM motor scores, but associated costs were higher in those with dual diagnosis.

Individuals with nontraumatic SCI have reduced LOS and less functional improvement with rehabilitation as compared to those with traumatic SCI, although additional studies that better control for nontraumatic subtypes are required.

5.4 Effect of Gender and Race on Rehabilitation Outcomes

Potentially, there are many additional factors that may affect rehabilitation outcomes following inpatient SCI rehabilitation. Two of these factors include gender and race, although neither has been examined comprehensively. With respect to gender effects, studies investigating rehabilitation outcomes associated with women have focused on long-term psychosocial outcomes associated with issues such as marriage or motherhood or issues associated with community and vocational reintegration (Westgren & Levi 1994; DeVivo et al. 1995; Shackelford et al. 1998; Krause et al. 1998). Studies of the effects of race on rehabilitation outcomes have been limited to evaluations of the differences between whites and African Americans using US Model Systems data (Meade et al. 2004a; Putzke et al. 2002), although as with studies of gender, investigations of the effects of race have focused more on vocational issues and satisfaction with life (James et al. 1993; Krause et al. 1998; Krause 1998; Meade et al. 2004b).

Table 8 Individual Studies – The Effect of Gender on Rehabilitation Outcomes

<table>
<thead>
<tr>
<th>Author Year</th>
<th>Country</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenwald et al. 2001 USA</td>
<td>Case Control</td>
<td>Initial N=1074; Final N=1074</td>
<td></td>
<td>Population: Traumatic SCI from US Model Systems database; matched male vs female by level of function, AIS and age: 50% were 18-34 years, 42% were 36-64 years and 8% were &gt;64 years old; tetraplegia, paraplegia; AIS A-D; 86% were admitted to Model systems within 21 days post-injury. Treatment: No treatment per se, outcomes associated with inpatient acute and rehabilitation care focusing on gender effects. 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.</td>
<td>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.</td>
</tr>
<tr>
<td>Author Year</td>
<td>Country</td>
<td>Research Design</td>
<td>Total Sample Size</td>
<td>Methods</td>
<td>Outcome</td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
<td>-----------------</td>
<td>------------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>Krause et al 2006</td>
<td>USA</td>
<td>Observational</td>
<td>Initial N = 1342, Final N=1278</td>
<td>rehabilitation.</td>
<td>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.</td>
</tr>
<tr>
<td>Furlan et al. 2005</td>
<td>Canada</td>
<td>Case series</td>
<td>N=55</td>
<td>Population: 72.3% response rate to a survey of outpatients from a large SE US rehabilitation hospital. Mean age=41.6yrs; Gender &amp; Race: 75% white, 74% male, 56% white male, 21% white female, 18% African American men, 5% African American females; Injury Duration: Mean = 9.7 years; 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%. Treatment: 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: 3 general health indicators from the Behavioural 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).</td>
<td>1. Differences in gender were seen in the significantly higher rates of nonroutine 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 nonroutine physician visits by females than males, however this gender effect was substantially less than that evident with the mediating variables of income and education.</td>
</tr>
<tr>
<td>Author Year</td>
<td>Country</td>
<td>Research Design</td>
<td>Total Sample Size</td>
<td>Methods</td>
<td>Outcome</td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
<td>-----------------</td>
<td>-------------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>Scivoletto et al. 2004</td>
<td>Italy</td>
<td>Case Control</td>
<td>N=281</td>
<td>diving accident = 11.8%. <strong>Treatment</strong>: Data from acute cervical traumatic SCI patients was retrospectively analyzed to assess gender differences. <strong>Outcome Measures</strong>: Secondary complications, AIS.</td>
<td>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.</td>
</tr>
<tr>
<td>Sipski et al. 2004</td>
<td>USA</td>
<td>Case series</td>
<td>N=14433</td>
<td>Population: SCI: Mean age = 50.4 yrs; Gender (traumatic): males = 82, females = 23; Gender (nontraumatic): 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. <strong>Treatment</strong>: Data from SCI patients was retrospectively evaluated to examine sex related differences. <strong>Outcome Measures</strong>: Admission scores, discharge scores, length of stay, efficiency.</td>
<td>1. Completeness of injury was significantly higher in: • Males than females (p=0.007). • Younger females (younger than 40 years) than older females (older than 50 years), p&lt;0.001. 2. AIS motor scores from admission to 1 year post injury, were significantly higher for women than men with complete (p=0.035) or incomplete (p=0.031). 3. At 1 year post injury, improvement of motor scores on the left side was significantly greater for women than for men with complete injuries (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.</td>
</tr>
<tr>
<td>Author Year; Country</td>
<td>Research Design</td>
<td>Total Sample Size</td>
<td>Methods</td>
<td>Outcome</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------</td>
<td>------------------</td>
<td>---------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>Meade et al. 2004 USA</td>
<td>Case Control</td>
<td>Initial N=628; Final N=628</td>
<td>Population: Traumatic SCI from US Model Systems database; matched white vs African American subjects matched by level of function, ASIA Impairment Scale, age and primary care sponsor: Mean age = 34.2 yrs; Gender: males = 84.2%, females = 14.7%; Level of injury: paraplegia, tetraplegia; Severity of injury: AIS: A-D. Treatment: No treatment per se, but various outcomes associated with inpatient acute and rehabilitation care focusing on race effects by comparing outcomes of African Americans and whites. Outcome Measures: AIS motor index scores, FIM motor scores, Medical complications, discharge disposition, medical procedures and medical management. Collected at admission to acute care and admission to and discharge from rehabilitation.</td>
<td>1. No significant differences between whites vs African Americans 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&lt;0.001) and be catheter free in comparison to caucasians. 5. Whites were more likely to receive spine surgeries (p&lt;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.</td>
<td></td>
</tr>
<tr>
<td>Putzke et al. 2002 USA</td>
<td>Case Control Study 1: Initial N=2438; Final N=374 Study 2: Initial N=3301; Final N=316</td>
<td>Study 1: Mean age = 34.8 yrs (white) &amp; 35.3 yrs (African American); Gender(both groups): males = 90%, females = 10%; Study 2: Mean age = 37.7 (white) &amp; 37.8 (African American) yrs: Gender(both groups): males = 93%, females = 7%. Treatment: No treatment per se, but 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</td>
<td>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&gt;0.05). 2. The 2 groups were significantly different (p&lt;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 1. No significant differences were seen with SWLS, SF-12 and CHART (p=0.25). 2. None of the medical outcome variables differed significantly (p&gt;0.05) with race, including days rehospitalized and number of rehospitalizations in the previous year, impairment level, and total medical complications. 3. 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).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Author Year; Country Research Design Total Sample Size</td>
<td>Methods</td>
<td>Outcome</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------</td>
<td>---------</td>
<td>---------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Krause et al 2006 USA Case Series Initial N = 1342 Final N=1278</td>
<td>admission, discharge or at annual follow-up (Study 2 only).</td>
<td>4. As with Study 1, both groups differed significantly on numerous demographic and injury-related factors (p&lt;0.001).</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Population:** 72.3% response rate to a survey of outpatients from a large SE US rehabilitation hospital. Mean age=41.6yrs; Gender & Race: 75% white, 74% male, 56% white male, 21% white female, 18% African American men, 5% African American females; Injury Duration: Mean = 9.7 years; 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%.

**Treatment:** 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:** 3 general health indicators from the Behavioural 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. 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.

**Note:** AIS=ASIA Impairment Scale; FIM=Functional Independence Measure; MVC=motor vehicle collision

**Discussion**

**Gender**

Greenwald et al. (2001) employed a mixed, block design, matching male and female subjects so as 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 1988-1998 by using US Model Systems data culled from 20 different SCI centers 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. 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.

Studies have found mixed evidence for gender-related differences in the incidence of DVT in the spinal cord injured population. Greenwald et al. (2001) demonstrated a significantly higher rate of DVT in men while Furlan et al. (2005) found a higher trend of DVT in women.
The prevalence of psychiatric complications was found to be higher in women than men in the spinal cord injured 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. 2003) 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.

Sipski et al. (2004) demonstrated that as a whole no gender related differences were seen in ASIA score improvement 1 year after injury. However, in contrast to the 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 more FIM motor improvement than women by discharge.

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., nonroutine 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.

Race

Similar case control designs employing matched groups of Caucasians vs. African Americans from the US 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 vs. Caucasians but these were generally accounted for by socio-demographic and etiological differences associated with these groups (Putzke et al. 2002; Meade et al. 2004). 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 (Putzke et al. 2002; Meade et al. 2004). It is likely that these etiological and socio-demographic variations have far more to do with differences seen in rehabilitation outcomes than race.

Similarly, Krause et al (2006) observed that, post-discharge, African Americans in a Southeastern US 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.

Conclusions

*There is level 3 evidence from a single study that there is no difference with respect to gender on discharge destination, rehabilitation LOS and neurological or functional*
outcomes associated with rehabilitation, although there is conflicting level 4 evidence from individual studies that indicate gender differences for some of these outcomes.

There is level 3 evidence that there is no difference with respect to race (Caucasians vs 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, rehabilitation LOS and neurological or functional status in US Model Systems data.

6.0 Specialized vs General SCI Units (Acute Care)

Donovan et al. (1984) contend that best practice for SCI care consists of a situation in which every individual sustaining a SCI is admitted to an integrated, comprehensive system where expertise, facilities and equipment are focused on optimal patient care and cost effectiveness. At the other extreme is the situation condemned by Bedbrook and Sedgley (1980), of piecemeal care for those with SCI characterized by “the occasional patient being treated by the occasional doctor”. In practice, care provided by most SCI centers likely falls somewhere in between these extremes of specialized vs. general care. The present section outlines the studies that are focused on examining the hypothesis that care provided through specialized SCI centers is more efficient and effective than that delivered at general centers.

The reader should note that while the majority of these studies were conducted from rehabilitation centers, the experimental manipulation of interest concerns the degree to which specialist care is delivered during the acute care period.

Table 10 Individual Studies – Specialized vs General SCI Units

<table>
<thead>
<tr>
<th>Author Year</th>
<th>Country</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smith 2002</td>
<td>UK</td>
<td>Observational</td>
<td>N=800</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Population:** Patients that received rehabilitation within the UK National Health Service.

**Treatment:** Spinal cord injured patients who received rehabilitation from either a specialized spinal injury units (SIU) or non-specialized spinal injury units completed a postal self report questionnaire.

**Outcome Measures:** Functional outcome, satisfaction, social activity.

1. 13.6% of patients did not use the SIU system.
2. SIU group had significantly lower:
   - Superficial pressure sores (p=0.048).
   - 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).
<table>
<thead>
<tr>
<th>Author Year</th>
<th>Country</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tator et al. 1995</td>
<td>Canada</td>
<td>Case Control</td>
<td>Initial N=552; Final N=552</td>
<td>Population: Traumatic SCI; 201/220 consecutive admissions to a newly established specialized interdisciplinary acute SCI unit vs 351 admissions to one of two general hospital trauma units; tetraplegia, paraplegia; incomplete, complete; Male/female ~ 4/1; Median age - 27 years (SCI Specialist unit), 32.0 years (general hospital). Treatment: Comparison of those treated in a SCI specialist spinal unit (1973-1981) vs a general hospital trauma unit (1947-1973). Outcome Measures: LOS, Mortality rate, Cord Injury Neurological Recovery Index. All collected at 6 months (complete) or 12 months (incomplete).</td>
<td>1. Subjects who were admitted to the specialized SCI unit had significantly shorter acute care LOS than those admitted to the general units (p&lt;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&lt;0.001).</td>
</tr>
<tr>
<td>Heinemann et al. 1989</td>
<td>USA</td>
<td>Case Control</td>
<td>Initial N=338; Final N=338</td>
<td>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: Modified Barthel index (MBI), MRSCICS Patient Functional Level Scheme, Length of Rehabilitation Stay (LOS), Efficiency of Rehabilitation Gains (MBI / natural logarithm of LOS)</td>
<td>1. Those receiving specialized care made functional gains with significantly greater efficiency and were transferred to rehabilitation significantly faster (p&lt;.001). 2. A significantly greater number of people were transferred from general centers with spine instability than from specialized SCI centers (p=.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.</td>
</tr>
<tr>
<td>Yarkony et al. 1985</td>
<td>USA</td>
<td>Population: Traumatic SCI admitted to a specialized</td>
<td></td>
<td></td>
<td>1. Those admitted from the specialized SCI unit had</td>
</tr>
<tr>
<td>Author Year Country</td>
<td>Research Design</td>
<td>Total Sample Size</td>
<td>Methods</td>
<td>Outcome</td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------</td>
<td>-------------------</td>
<td>---------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>Case Control</td>
<td>Initial N=181; Final N=181</td>
<td>rehabilitation unit; Males (n=149) and females (n=32); Avg age 28 years; Tetraplegia (54%), paraplegia (46%); incomplete (58%), complete (42%).</td>
<td>significantly improved joint motions (i.e., reduced contractures). More had normal range of motion (p&lt;0.05) and fewer abnormalities.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Treatment: Comparison of those treated acutely in a specialized interdisciplinary spinal unit (n=90) vs a general hospital unit (n=91).</td>
<td>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&lt;0.01). Those admitted earlier to rehabilitation had reduced numbers of contractures (p&lt;0.01).</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outcome Measures: Joint motion, time to rehabilitation admission, all collected at admission to rehabilitation.</td>
<td>3. Those with tetraplegia had an increased incidence of contractures (p&lt;0.01).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Donovan et al. 1984</td>
<td>USA / Australia</td>
<td>Traumatic SCI, admitted to a specialized, integrated rehabilitation unit in Australia (n=66) vs those admitted to the US Model Systems (n=1606); tetraplegia, paraplegia; incomplete, complete.</td>
<td>1. Subjects who were cared for in the integrated, specialized unit (Australia) encountered the fewest complications. (no statistical analysis was performed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case Control</td>
<td>Initial N=1,672; Final N=1,672</td>
<td>Treatment: Those treated in an integrated, specialized interdisciplinary spinal unit (Australia) admitted &lt;48 hours post-injury vs those admitted to the US Model Systems at 1-15, 16-30, 31-45 or 46-60 days post-injury (reflecting progressively less specialized care).</td>
<td>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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outcome Measures: Incidence of 7 complications collected at 1-15, 16-30, 31-45 or 46-60 days post-injury.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: LOS=Length of stay

**Discussion**

The majority of the studies examining the effect of specialist vs. general SCI care settings focused on this issue during 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 five 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, 46-60 days) and compared with those being admitted to specialist SCI centers from more general care settings at similar time periods. Most striking was the absence
of decubitis ulcers during any time period for those under more specialized care vs. a progressively greater incidence for those with greater time spent in general care. No statistical analysis was conducted for this study. Smith (2002) conducted a postal survey (i.e., observational study) 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 vs 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).

In the remaining 3 studies all comparisons were limited to specialized vs. general acute care and were retrospective in nature. Two of these studies compared subjects as they were being admitted for comprehensive rehabilitation (Yarkony et al. 1985; Heinemann et al. 1989). In both studies, patients were transferred significantly faster to comprehensive inpatient rehabilitation from more specialized acute care settings than from general hospital settings. In the remaining study by Tator et al. (1995), the same issue was investigated by examining outcomes associated with a seven year experience of a newly developed specialist SCI unit as compared to historical data culled from pre-existing trauma units reflecting more general settings (Tator et al. 1995). In this study, subjects were also transferred to rehabilitation faster from the specialist SCI unit resulting in a reduced length of stay (LOS) in acute care.

In general, all of these studies 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 (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. 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 one study has examined the functional benefits realized during rehabilitation associated with SCI-specific acute care vs. that delivered in more general settings. Heinemann et al. (1989) used the Modified Barthel Index to show that those individuals receiving more 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 vs. general groups for either admission or discharge functional levels nor were significant differences seen with LOS. There was, however, 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. Functional benefits associated with early admission and reduced LOS will be reviewed in the next section.

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; Yarkony et al. 1985; Heinemann et al. 1989). 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 a Grade 3 level of evidence and some findings have been reduced to Grade 4 if not corroborated and involving 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 - Benefits of Specialized vs General SCI Units

*Based on several retrospective, case-control studies there is level 3 evidence 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 that individuals cared for in interdisciplinary, specialist acute care SCI units have fewer complications upon entering and during their rehabilitation programs.*

*There is level 4 evidence that individuals initially cared for in interdisciplinary, specialist acute care SCI units make more efficient functional gains during rehabilitation (i.e., more or faster improvement).*

*There is level 4 evidence that individuals cared for in interdisciplinary, specialist SCI units have reduced mortality.*

7.0 Early vs 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 (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 vs 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 vs rehabilitation perspective. For the present review, all studies which examine this question by comparing 2 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 11 Individual Studies – Early vs Delayed Admission (Acute Studies)

<table>
<thead>
<tr>
<th>Author Year Country</th>
<th>Research Design</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daylan et al. 1998 USA</td>
<td>Case Control</td>
<td>Population: 482 men and women with traumatic SCI admitted to a US Model Systems SCI Centre with specialized SCI acute care and rehabilitation services. Subjects included those with tetraplegia (256) &amp; paraplegia (226) and AIS A, B, C (362) &amp; D (120). Treatment: No tx per se, comparison of those admitted 1. (&lt; 24 hours post injury) vs 2. (&gt; 24 hours – 60 days post-injury) to a specialized spinal acute care and rehabilitation unit. Outcome Measures: Incidence of contractures during initial post-traumatic hospitalization.</td>
<td>1. Subjects who were admitted earlier (&lt;24 hours) had significantly fewer contractures than those admitted later (&gt;24 hours – 60 days) (p=0.05). 2. Other factors associated with an increased incidence of contractures included tetraplegia vs paraplegia (p&lt;0.01), presence of a pressure ulcer (p=0.05), co-existence of head injury (p&lt;0.05).</td>
</tr>
<tr>
<td>DeVivo et al. 1990 USA</td>
<td>Case Control</td>
<td>Population: 661 people with SCI admitted to a US Model Care System Centre with specialized SCI rehabilitation services. Subjects included those with tetraplegia and paraplegia and also those with incomplete vs complete injuries but frequencies were not provided. Average ages for early vs delayed admission groups were 29.5 and 32.0 years old respectively. Treatment: No tx per se, comparison of those admitted earlier (&lt; 24 hours post injury) vs later (&gt; 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: Length of Stay (LOS), Hospital charges,</td>
<td>1. Those with complete paraplegia (p=0.0169) &amp; incomplete tetraplegia (p=0.0001) admitted earlier (&lt;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 vs late admission groups. A few differences for</td>
</tr>
</tbody>
</table>
Incidence of medical complications, Neurologic recovery, Mortality all collected at Discharge.

<table>
<thead>
<tr>
<th>Author Year</th>
<th>Country</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amin et al. 2005</td>
<td>England</td>
<td>Case Control</td>
<td>Initial N=432; Final N=432</td>
<td>Population: SCI, tetraplegia, paraplegia, traumatic. Treatment: No tx per se, 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 (&gt;3 days) and between referral and admission (&gt;7 days). Outcome Measures: LOS.</td>
<td>1. Those admitted with a delay (&gt;7 days) following referral had significantly longer LOS (p&lt;.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&lt;0.0001). 3. Those who were admitted with a delay between injury and referral (&gt;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.</td>
</tr>
</tbody>
</table>

| Scivoletto et al. 2005 | Italy | Population: SCI, tetraplegia, paraplegia, complete, incomplete, | 1. Those admitted earliest (<30 days) had significantly |

Note: AIS=ASIA Impairment Scale; LOS=Length of Stay
<table>
<thead>
<tr>
<th>Author Year</th>
<th>Country</th>
<th>Research Design</th>
<th>Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case Control</td>
<td>Japan</td>
<td>Case Control</td>
<td>Initial N=150; Final N=150</td>
<td>traumatic. Treatment: No tx per se, comparison of those admitted to a specialized Spinal Rehabilitation unit at one of 3 time periods following injury (&lt;30 days, 31-60 days, &gt; 60 days). Outcome Measures: LOS, AIS motor scores and impairment grade, Barthel Index (BI), Rivermead Motor Index (RMI), Walking Index for SCI (WISCI). Efficiency measures for all were calculated by dividing by LOS.</td>
<td>performance on activities of daily living (i.e., Barthel Index scores) at discharge than those with longer delays (&gt;60 days) (p=.006). They also demonstrated significantly greater changes (p=.003) and greater efficiency (p&lt;.001) for the Barthel Index. 2. Those admitted the earliest (&lt;30 days) had significantly better mobility (i.e., RMI) at discharge than those with longer delays (&gt;60 days) (p=.03). They also demonstrated significantly greater changes (p=.001) and greater efficiency (p=.04) for the RMI. 3. There were no significant differences between the early vs later admissions with respect to walking (WISCI) or ASIA motor scores (p=.63 or p=.81). 4. Those admitted earliest had the shortest LOS; these differences were not significant (p=.15).</td>
</tr>
<tr>
<td>Sumida et al. 2001</td>
<td>Japan</td>
<td>Case Control</td>
<td>Initial N=139; Final N =123</td>
<td>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 tx per se, comparison of those admitted earlier (&lt; 2 weeks post injury) vs later (&gt; 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.</td>
<td>1. Subjects who were admitted earlier (&lt;2 weeks) had significantly shorter LOS than those admitted later (p&lt;0.0005). 2. FIM gain (p&lt;0.0001) and FIM efficiency (p&lt;0.0001) were significantly greater for subjects admitted earlier vs later. Note: the early admission subjects had lower initial motor and total FIM scores than did the delayed admission group (p&lt;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&lt;.05).</td>
</tr>
<tr>
<td>Aung &amp; El Masry 1997</td>
<td>UK (Wales)</td>
<td>Population: 173 men (mean age 35.5) and 46 women (mean age</td>
<td>1. Subjects with paraplegia who were admitted earlier (&lt;1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Author Year Country</td>
<td>Research Design</td>
<td>Methods</td>
<td>Outcome</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------</td>
<td>----------------</td>
<td>---------</td>
<td>---------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case Control</td>
<td>USA</td>
<td>Initial N=219; Final N=219</td>
<td>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). <strong>Treatment:</strong> No tx per se, comparison of those admitted 1. (&lt; 1 week post injury) vs 2. (&lt; 2 month) vs 3. (&gt; 2 months) to a specialized spinal acute care and rehabilitation unit. <strong>Outcome Measures:</strong> LOS, incidence of secondary complications all collected at discharge (i.e., during initial post-traumatic hospitalization).</td>
<td>1. Those admitted earlier had significantly shorter LOS than those admitted later (p&lt;0.05). 2. Subjects with tetraplegia who were admitted earlier (&lt;1 week) had significantly shorter LOS than those admitted later (&gt;2 months) (p&lt;0.05). 3. The incidence of most secondary conditions did not differ between early vs later admissions for those with paraplegia or tetraplegia. However, those with paraplegia or tetraplegia did have lower incidence of pressure sores with earlier admission (&lt;1 week) (p&lt;0.001).</td>
<td></td>
</tr>
<tr>
<td>Oakes et al. 1990</td>
<td>Italy</td>
<td>Case Control</td>
<td>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); Average ages for groups were 27.2 –32 years old. <strong>Treatment:</strong> No tx per se, comparison of those admitted earlier (&lt; median) vs later (&gt; median) to a specialized integrated spinal unit (i.e., combined acute care and rehabilitation). Subjects were grouped by tetra vs para and by early vs late admission by median admission values of 11 (Tetra) vs 21 (Para) days. <strong>Outcome Measures:</strong> LOS, incidence of medical complications, incidence of surgical intervention.</td>
<td>1. Those admitted earlier had significantly shorter total hospitalization LOS (p&lt;.01). 2. Those admitted earlier with tetraplegia had fewer medical complications and less frequent spinal surgery vs 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&lt;.01) and paraplegia (p&lt;.05) in a re-analysis of the sample with groupings based on admissions &lt; 24 hours vs &gt; 24 hours post-injury.</td>
<td></td>
</tr>
<tr>
<td>Scivoletto et al. 2006</td>
<td>Italy</td>
<td>Case series</td>
<td>Population: Mean age=55.1yrs; Gender: males=71, females=46; Level of injury: C=37, T=59, LS=21; Severity of injury: AIS A=36, C=53, D=28; Etiology of injury: nontraumatic=81, traumatic=36 <strong>Treatment:</strong> 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.</td>
<td>1. Delayed admission still resulted in significant improvement in: • BI, WISCI, RMI, Motor scores, gait (p&lt;0.001). 2. Mean LOS was 99.7±62.5 days (median 100 days). 3. At discharge 49 of 117 patients were able to achieve normal bladder control, 28 used clean intermittent catherization and 34 self intermittent catherization. 4. 90% (104) patients returned</td>
<td></td>
</tr>
</tbody>
</table>
Patients also received water therapy 45 mins twice weekly and occupational therapy 45 min 3day/week. **Outcome Measures:** Barthel Index (BI), Walking Index for Spinal Cord Injury (WISCI), Rivermead Mobility index (RMI), bladder management, discharge destination, AIS. All collected at admission and discharge.

5. 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).

**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 13.

### Table 13 Studies Examining Delayed Admission to SCI Unit (Comparison Studies Only)

<table>
<thead>
<tr>
<th>Study</th>
<th>Experimental Groups (time post-injury)</th>
<th>Outcome Measure</th>
<th>Result</th>
</tr>
</thead>
</table>
| Amin et al. 2005  | • <= 3 days  
                   • > 3 days  
                   or  
                   • <= 7 days from referral*  
                   • > 7 days from referral  | LOS                                    | -      |
|                   | • <= 3 days  
                   • > 3 days  
                   or  
                   • <= 7 days from referral*  
                   • > 7 days from referral  | LOS                                    | +      |
| Scivoletto et al. 2005 | • <= 30 days*  
                    • 30-59 days  
                    • > 60 days  | LOS                                    | ~      |
|                   | • <= 30 days*  
                    • 30-59 days  
                    • > 60 days  | Functional Status                     | +      |
|                   | • <= 30 days*  
                    • 30-59 days  
                    • > 60 days  | Neurological Status                   | -      |
| Sumida et al. 2001 | • <= 2 weeks*  
                     • > 2 weeks  | LOS                                    | +      |
|                   | • <= 2 weeks*  
                     • > 2 weeks  | Functional Status                     | +      |
|                   | • <= 2 weeks*  
                     • > 2 weeks  | Neurological Status                   | +      |
| Daylan et al. 1998 | • <= 24 hours*  
                     • > 24 hours  | Secondary complications (contractures) | +      |
| Aung & El Masry 1997 | • <= 1 week*  
                     • < 2 months  | LOS                                    | +      |
|                   | • <= 1 week*  
                     • < 2 months  | Secondary complications               | -      |
| DeVivo et al. 1990 | • <= 24 hours*  
                     • > 24 hours  | LOS                                    | +      |
|                   | • <= 24 hours*  
                     • > 24 hours  | Secondary complications               | -      |
|                   | • <= 24 hours*  
                     • > 24 hours  | Neurological Status                   | ~      |
| Oakes et al. 1990 | • <= 11 days (for tetra)*  
                     • > 11 days  
                     or  
                     • <= 21 days (for para)*  
                     • > 21 days  | LOS                                    | +      |
|                   | • <= 11 days (for tetra)*  
                     • > 11 days  
                     or  
                     • <= 21 days (for para)*  
                     • > 21 days  | Secondary complications               | + (tetra only) |
Two acute studies were reviewed which each employed retrospective, 2 group (case control) designs with a definition of 24 hours as to what constituted an “early” vs a “delayed” admission (DeVivo et al. 1990; Dalyan et al. 1998). Each study examined a fairly large cohort admitted to a multidisciplinary, specialized SCI unit (i.e., US model system center) within 24 hours post-injury vs 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 vs. 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. Dalyan et al. (1998), in a study focusing on the development of contractures, noted a reduced incidence of contractures for those admitted within 24 hours to a specialized unit.

Of the studies examining time periods longer than one week (i.e., post-acute), five studies have been reviewed (Oakes et al. 1990; Aung & el Masry 1997; Sumida et al. 2001; Amin et al. 2005; Scivoletto et al. 2005). The initial admission delays examined ranged from 1 week (Aung & el Masry 1997) to 1 month (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 to LOS was statistically significant for all studies but one; for which it was reported as a trend (p=0.15). This study examined the longest delay of 1 month (Scivoletto et al. 2005).

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 Barthel Index (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 Functional Independence Measure (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 vs. 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 vs 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” vs “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 - Benefits of Early vs Later Admission

Based on several retrospective, case-control studies there is level 3 evidence 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 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 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 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 (Ernst et al. 1998; Cox et al. 2001; Dryden et al., 2004). In a recent review, Bloemen-Vrencken et al. (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 5 of these being identified as either experimental or quasi-experimental in nature. Of these, 2 studies examined the effect of various models of care associated with routine after-care (Dinsdale et al. 1981; Dunn et al. 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 et al. 1999; Phillips et al. 1999; Phillips et al., 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.

Cox et al. (2001) performed a needs assessment of 54 community-dwelling individuals with SCI using structured telephone interviews and reported a perceived high need for a specialist, multidisciplinary SCI outreach service. 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 14 Outpatient and Follow-up Care

<table>
<thead>
<tr>
<th>Author Year Country Score Research Design Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Models of Outpatient / Follow-up Care</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dunn et al. 2000 USA Downs &amp; Black score=12 Prospective Controlled Trial (inadequate control) Initial N=371; Final N=371</td>
<td>Population: People with SCI receiving SCI-specialist follow-up care (N=235) vs those not (N=136); Age = 56.6 vs 47.9; Gender = 99% Male vs 66% Male; paraplegic, tetraplegic; complete, incomplete; Time since injury = 19.4 vs 18.2 years. Treatment: Follow-up care (routine check-ups in SCI Outpatient Clinic) vs no Follow-up care (presumably problem-based primary care). Outcome Measures: Secondary Condition Surveillance Instrument</td>
<td>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.</td>
</tr>
</tbody>
</table>
(SCSI), Check Your Health (CYH) Questionnaire. One time survey of both groups.

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Score</th>
<th>Design</th>
<th>Initial N</th>
<th>N</th>
<th>Treatment</th>
<th>Population</th>
<th>Outcome Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloemen-Vrencken et al. 2007</td>
<td>The Netherlands</td>
<td>Downs &amp; Black score = 21</td>
<td>Prospective Controlled Trial</td>
<td>Initial N=149</td>
<td>N=62 (31 matched subjects in each group)</td>
<td>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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lugo et al. 2007</td>
<td>Columbia</td>
<td>Downs &amp; Black score = 15</td>
<td>Pre-Post</td>
<td>Initial N=208 (Period 1)</td>
<td>N=42 (Period 2)</td>
<td>1. Motor FIM scores progressively increased significantly from admission to first month and after 1 year of rehabilitation (p&lt;0.01) showing most marked increase between admission and months 2-3. 2. Patients in AIS A and B groups reached motor FIM ceiling scores in the 18th month, while those in the C, D, E group reached ceiling in the 12th month. 3. AIS motor scores progressively increased from admission over 18 months, however, persons with cervical injuries had most marked increases between admission and months 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).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telehealth Applications in Follow-up Care</td>
<td>Dallolli et al. 2008</td>
<td>Italy, Belgium, UK</td>
<td>PEDro score = 6</td>
<td>RCT</td>
<td>Initial N=137</td>
<td>N=127 (62 vs 65, telemedicine vs control)</td>
<td>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&lt;0.01) as well as some</td>
<td></td>
</tr>
</tbody>
</table>
**Treatment:** Usual follow-up care vs the same combined with 8 weekly telemedicine sessions followed by 9 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 between groups in prevalence of secondary complications.  
2. Persons receiving the telemedicine contacts were significantly more satisfied with their care than those receiving routine follow-up care (p<0.001).

| Phillips et al. 1999 | Population: 35 subjects (26 male, 9 female); mean age: 33±12.1 yrs; newly spinal cord injured. | Treatment: Subjects were recruited for one of 3 groups: i) Video group: received weekly counselling sessions for 10-12 wks using AT&T Picasso Still-Image video unit for the first 6-8wks followed by 4-6 wks of weekly telephone counselling sessions; ii) Telephone group: telephone counselling for 10 wks; iii) Standard care group.  
**Outcome measures:** Pressure ulcer incidence; frequency of health care utilization. All groups were surveyed every 2-3 mths. |
|---------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| USA                 | Prospective controlled trial                                                                  | 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). |
| Downs and Black Score=17 N=35 |                                                                                                  |                                                                                                  |

| Vesmarovich et al. 1999 | Population: 8 male subjects; age: 38-78 yrs; Injury: cervical (n=5) or thoracic (n=3). | Treatment: Weekly telerehabilitation visits using Picasso Still-Image Videophone: 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; subjective satisfaction assessment by patients, families and care providers. |
|--------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| USA                      | Pre-post                                                                                        | 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. Clinicians identified several technical concerns throughout project but these were solved. |
| Downs and Black Score=4 Pre-post N=8 |                                                                                                  |                                                                                                  |

**Note:** AIS=ASIA Impairment Scale; FIM=Functional Independence Measure; SCIM=Spinal Cord Independence Measure; UTI=Urinary Tract Infection

**Discussion**

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, 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.

Due to financial constraints in the developing country of Columbia, Lugo et al (2007; N=42) reported on prospectively planned FIM and ASIA outcomes resulting from an interdisciplinary outpatient program of rehabilitation for individuals with SCI. An average 13.5 day in-patient rehabilitation program was augmented with 18 months of follow-up (at 1, 3, 6, 12 & 18 month time points). Although there was a lack of accessibility to continuous therapy, 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 that provisions are made for program accessibility (i.e. transportation).

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. (2008) conducted a multi-centre RCT (n=127) across 3 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 3 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 (1999) and colleagues published 2 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 3 groups with respect to doctor/hospital/ER 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%.

Conclusions

There is limited level 4 evidence 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 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 that regular and accessible interdisciplinary follow-up can result in achieving functional goals where protocolized SCI care is unavailable.

There is limited Level 1 evidence from a single study that teledermcience videoconferencing as an adjunct to routine follow-up care improves patient satisfaction and may lead to enhanced functional outcomes.
Routine, comprehensive, specialist follow-up services may result in improved health.

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

Telehealth applications such as telemedicine may enhance patient satisfaction with follow-up services and also may improve functional outcomes.

8.2 Rehospitalization and Healthcare Utilization after Initial Rehabilitation in SCI

Persons with SCI are at greater risk for numerous secondary health complications than the general population and therefore are at far greater likelihood of being admitted to hospital or seeking medical care for one reason or another. At least some of the causes for these admissions or other forms of healthcare utilization have been deemed as preventable (e.g., pressure sores, UTIs) and therefore there has been much interest in understanding the patterns and antecedents for rehospitalization/healthcare utilization so as to inform effective preventative strategies.

Table 15 Individual Studies – Rehospitalization and Healthcare Utilization

<table>
<thead>
<tr>
<th>Author Year Country Research Design Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rehospitalization</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Popula...</td>
<td>1. 90% of patients were discharged home from acute rehabilitation.</td>
</tr>
<tr>
<td></td>
<td>Treatment: Retrospective analysis of cases of traumatic SCI for persons with anniversary dates of 1, 5, 10, 15 or 20 years post-discharge occurring between 1995-2002 within the US Model Systems database.</td>
<td>2. The most common reasons for rehospitalizations included:</td>
</tr>
<tr>
<td></td>
<td>Outcome Measures: Discharge destination, causes for rehospitalization, predictors of rehospitalization.</td>
<td>- Diseases of the genitourinary system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Diseases of skin and subcutaneous tissue.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Diseases of the respiratory system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Other unclassified diseases.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Diseases of the musculoskeletal system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. At first year follow up the average number of rehospitalizations were significantly higher than other follow-up years (p&lt;0.001). Rate was 55% in first year and 36-38% thereafter.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Rehospitalization rates were not significantly different among the different age groups.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. At 1 year rehospitalization was significantly related to:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Lower motor FIM scores (p=0.000).</td>
</tr>
</tbody>
</table>

Cardenas et al. 2004 USA Observational N (Initial)=8668; N (End)=1252
<table>
<thead>
<tr>
<th>Author Year</th>
<th>Country</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlifue et al. 2004</td>
<td>USA</td>
<td>Case series</td>
<td>N = 7981</td>
<td>Population: Traumatic SCI; Age 3254±40, 2908±41; Level of injury: All levels; Severity of injury: AIS: A-D. Treatment: Retrospective analysis of cases of traumatic SCI with onset between 1973-1998 from the US Model Systems database. Outcome Measures: Number of &amp; causes for rehospitalization, days rehospitalized, number of pressure ulcers, self-assessed health status and Satisfaction with Life Scale collected at 1, 5, 10, 15, 20 and 25 years post-injury.</td>
<td>• Patients funded by state or federal programs (p=0.010). 6. At 5 years 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. 7. At 10 year follow-up, only payer remained significantly related to rehospitalization rates (p=0.004).</td>
</tr>
<tr>
<td>Jaglal et al. 2009</td>
<td>Canada</td>
<td>Case Series</td>
<td>N=559</td>
<td>Population: Traumatic SCI; Age: 47.3±18.4 years; Gender: males = 423, females = 136; Level of injury: Cervical = 350, Thoracic = 126, Lumbar = 62, Other = 21. Treatment: Retrospective analysis (population-based) of cases of traumatic SCI between 2003-2006 from 6 administrative healthcare databases (Province of Ontario). Outcome Measures: Rehospitalization rates, causes, predictors collected over a 1 year period following rehabilitation discharge.</td>
<td>1. Rate of rehospitalization was 41% in year 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 4. 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.</td>
</tr>
<tr>
<td>Author Year</td>
<td>Country</td>
<td>Research Design</td>
<td>Total Sample Size</td>
<td>Methods</td>
<td>Outcome</td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
<td>----------------</td>
<td>-------------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>Middleton et al. 2004</td>
<td>Australia</td>
<td>Case Series</td>
<td>N=432 (253 persons requiring one or more rehospitalizations)</td>
<td></td>
<td>physician visits and &gt;50 specialists visits following the initial admission</td>
</tr>
</tbody>
</table>

4. 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).


**Treatment:** 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 10-year study period (total readmissions = 977; 15,127 bed-days; avg length of stay = 15.5 days; median 5 days)

2. ~10% were readmitted five times or more

3. Overall rehospitalization rate in the first 12 months post discharge = 0.64 readmissions per person at risk and decreases to ~0.4 readmissions per person at risk 10 years post acute admission)

4. Average length of stay (ALOS) was significantly longer for those with AIS A, B and C (22.2 – 17.0 days) compared to AIS D (11.3 days)

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
<table>
<thead>
<tr>
<th>Author Year</th>
<th>Country</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savic et al. 2000</td>
<td>UK</td>
<td>Case series</td>
<td>N=198</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population: Mean age = 57.5 yrs; 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 yrs.</td>
<td>Treatment: SCI patients were interviewed three times from 1990-1996 and their medical records were reviewed.</td>
<td>Outcome Measures: Readmission rates, reasons for readmission, LOS, FIM score, CHART score.</td>
<td>(n = 47 (4.8%)); Endocrine (n = 7 (0.7%)); Psychiatric (n = 66 (6.8%)); Other (n = 270 (27.6%))</td>
<td>6. The most costly 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 ALOS = 65.9 days)</td>
<td>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&lt;0.0001)</td>
</tr>
</tbody>
</table>
### Author Year Country Research Design Total Sample Size

<table>
<thead>
<tr>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>D had significantly shorter LOS than patients with A, B or C grade ( p=0.005 ).</td>
<td></td>
</tr>
<tr>
<td>There was significant difference between hospitalized patients and non-hospitalized patients in:</td>
<td></td>
</tr>
<tr>
<td>- Patients hospitalized were paralyzed for 2 years longer than the non-hospitalized group ( p=0.012 ).</td>
<td></td>
</tr>
<tr>
<td>- Hospitalized patients had a lower FIM score than non-hospitalized ( p=0.031 ).</td>
<td></td>
</tr>
<tr>
<td>- Hospitalized patients had a lower CHART physical independence score ( p=0.003 ) and CHART occupation score ( p=0.001 ).</td>
<td></td>
</tr>
</tbody>
</table>

**Franceschini et al. 2003**  
Italy  
Case series  
Initial N=251  
Final N=146  

**Population:** All SCI patients with hospitalization between 1989-1994. Mean age = 37.8 yrs; 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 yrs; Traumatic = 74.7%, Nontraumatic 25.3%..  
**Treatment:** 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 years post-discharge.  

**Paker et al. 2006**  
Turkey  
Case series  
N=56  

**Population:** Rehospitalized SCI patients: Mean age = 35yrs; Gender: males = 39, females = 17; Level of injury: cervical = 13, thoracic = 27, lumbar = 16, paraplegia = 44, tetraplegia = 12; Severity of injury: AIS: A = 29, B = 9, C = 12, D = 6, complete = 29, incomplete = 27; Time since injury = 18.4 mnths.  
**Treatment:** Patient data was retrospectively reviewed.  
**Outcome Measures:** Reasons for  

1. 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%).  

1. 7.6% of patients were rehospitalized within the same hospital, of these 71% had been hospitalized at other hospitals making the determination of a true rate uncertain.  
2. Mean rehospitalization LOS was 72.21 days during the 5 year period.  
3. Cause of rehospitalization was:  
   - Spasticity in 25%.  
   - Pressure sores, 17.9%.
rehospitalization.

- Urinary tract infections, 16.1%.
- Spinal surgery, 8.9%.
- Urinary tract surgery, 5.4%.
- Pain, 5.4%.

4. Rehospitalization due to spinal surgery was significantly related to lower age (p=0.04).
5. Reason for rehospitalization was related to length of stay (p=0.07), ASIA score (p=0.06), mobility (p=0.09).

Population: Mean age = 32yrs; Gender: males = 42, females = 4; Level of injury: paraplegia=19, tetraplegia=27; Severity of injury: complete =16, incomplete=30

Treatment: 10 year data from acute traumatic SCI patients 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, 12 months, 24 months, 36 months and 10 years.

1. 9% mortality rate was seen within 3 yrs of study.
2. Life situation questionnaire mean scores remained consistent over the 10 years.
3. The highest percentage of medical service utilization (10 or more) was at 2 years, while the lowest was at the 10th year (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 years and 52% by the 10th year.
6. Only 11% of individuals required rehospitalization for longer than 28 days.
8. At 2 years, reasons for rehospitalization were directly related to SCI, while at 10th year SCI complications were not related to rehospitalization.
9. Pressure sore occurrence was highest at the 2nd year, however no significant change in the number of pressure sores occurred over time.
10. Half the patients reported no pressure sores over the study period, while 30% tended to have pressure sores at multiple points of time.
<table>
<thead>
<tr>
<th>Author Year Country</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guilcher et al. 2010 Canada</td>
<td>Case Control</td>
<td>N=1562</td>
<td>Population: Nontraumatic (n=1002) and Traumatic (n=560) SCI; Age at admission: 46.9±17.3 and 61.6±15.8 years; 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%. Treatment: Retrospective analysis (population-based) of cases of traumatic SCI between 2003-2006 from 3 administrative healthcare databases (Province of Ontario).</td>
<td>1. Mean # of overall physician visits was 31.2 and 29.7 for nontrauma and trauma respectively. 16.5 and 17.0 for specialist visits. In both cases there was no significant difference in # of visits between nontrauma and trauma 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 years 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).</td>
</tr>
<tr>
<td>Munce et al. 2009 Canada</td>
<td>Case Series</td>
<td>N=559</td>
<td>Population: Traumatic SCI; Age: 47.3±18.4 years; Gender: males = 423, females = 136; Level of injury: Cervical = 350, Thoracic = 126, Lumbar = 62, Other = 21. Treatment: Retrospective analysis (population-based) of cases of traumatic SCI between 2003-2006 from 5 administrative healthcare databases (Province of Ontario).</td>
<td>1. Women had significantly more physician visits than men (37.0 vs 30.0, p=0.006) 2. Women had significantly more visits to their family physician than men (15.4 vs 10.3, p&lt;0.001) 3. Men had significantly more visits to their physiatrists than women (6.6 vs 4.5, p=0.028) 4. Individual factors with highest likelihood (i.e., highest odds ratios) of ≥ 50 physician visits included: &gt;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). 5. Individual factors with highest likelihood (i.e., highest odds ratios) of ≥ 50 specialist visits included: direct discharge to chronic care (OR=11.52), direct discharge to rehabilitation (OR=2.45), in-hospital complication (OR=1.99).</td>
</tr>
</tbody>
</table>
Dryden et al. 2004  
Canada  
Case Control  
N=233 (1165 matched controls)

**Population:** Traumatic SCI; Median age: 34.0 years; Gender: males = 176; females = 57; Level of injury: Cervical = 117, Thoracic, Lumbar, Sacral or Cauda Equina = 98; Severity: Complete = 43, Incomplete = 69, Unknown = 121.  
**Treatment:** 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 6 year period post-injury.

1. 57.3% of persons were rehospitalized over the 6 year follow-up period with a median LOS of 4.0 days/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 year 1, declining to 8.0 by year 2 and to 4.0 by year 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 month follow-up and this was a greater mortality rate with SCI as compared to controls (p<0.001)  
5. Over the 6 year follow-up 47.6% were treated for a UTI, 33.8% for pneumonia, 19.7% for decubitus ulcer and 15.5% for septicemia

Note: AIS=ASIA Impairment Scale; FIM=Functional Independence Measure; LOS=Length of Stay; QoL=Quality of Life

**Discussion**

**Rehospitalization**

Of the nine papers reviewed across six distinct jurisdictions (i.e. Australia, Canada, Italy, Turkey, UK, USA), differences in methods of calculating readmission rates and specific inclusion criteria made comparisons tenuous at best. Regardless, it is apparent that hospital re-admission is a very significant issue across all regions with universally high re-admission rates (Savic et al. 2000; Cardenas et al. 2004; Charlifue et al. 2004; Dryden et al. 2004; Franceschini et al. 2003; Jaglal et al. 2009; Middleton et al. 2004; Paker et al. 2006; Dorsett and Geraghty 2008). Cardenas et al. 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% for subsequent anniversary years from 5-20 years post injury. This analysis was conducted on the large multi-centre US model systems dataset (n=8668) between 1995-2002. This was very similar to the rates reported by Charlifue et al. (2004) which was not surprising as she had examined the same database, albeit, over different years (1973-1998).

The only other high-quality, population-based data on which to base a comparison exists for the jurisdiction of Ontario, Canada. Jaglal et al. (2009) defined rehospitalizations over the first year after initial rehabilitation discharge, thereby circumventing the primary limitation of most other studies associated with a variable follow-up period. Multiple administrative healthcare databases were linked to overcome the other common limitation inherent in several other studies, that being the variances which may occur with participant self-report. These authors reported a rehospitalization rate of 27.5% - approximately half that reported in the US. This appears to be
similar to the rates reported over a somewhat similar time period in Queensland, Australia (n=46) by Dorsett and Geraghty (2008) as participants reported rehospitalization rates of ~18% from 0-6 months post-discharge (estimated from graph), ~25% from 6-12 months, ~31% for year 2, ~18% for year 3 and ~38% for year 10. Overall cumulative rehospitalization rates were reported at 32.6% over the first 2 years and 52% by the 10th year. Middleton et al. (2004) reported slightly higher 10 year (i.e., cumulative) rehospitalization rates for the jurisdiction of New South Wales, Australia (n=432) with 58.6% of persons with SCI being rehospitalized due to a SCI-related issue and an additional 10.8% being admitted to hospital for a non-SCI-related issue. Another report indicated an overall re-admission rate of 64% over 6 years involving 3 longitudinal interviews of community dwelling persons (n=198) with a mean of 33 years injury duration associated with two large SCI specialist centres in the UK (Savic et al. 2000).

One trend that can be gleaned from these reports is that the rehospitalization rates generally decline following the initial year or two post-discharge (Cardenas et al. 2004; Charlifue et al. 2004; Middleton et al. 2004). Regardless, in the context of informing initial rehabilitation practice, rehospitalization rates in the first year post-discharge are of particular importance and the data associated with the largest and highest-quality studies demonstrate a higher rate in the US versus other jurisdictions (i.e., Australia, Canada). It is difficult to speculate on why this may be the case given the variation between these countries in terms of health care and social systems although one suggestion has been that the high rehospitalization rate may be linked to a shortened rehabilitation stay, especially present in the US (Cardenas et al. 2004). It is certainly the case that the US has the shortest rehabilitation LOS than any other jurisdiction reporting data (See Section 4.2).

There is reasonable agreement for the primary reasons for hospital readmission following initial SCI inpatient rehabilitation across most studies (Cardenas et al. 2004; Dorsett and Geraghty 2008; Dryden et al. 2004; Franceschini et al. 2003; Jaglal et al. 2009; Middleton et al. 2004; Paker et al. 2006; Savic et al. 2000). All reports included 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 among the highest reasons for readmission. Other issues that were associated with significant rates of readmission included diseases of the respiratory system (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 found to be most prominent as a cause of readmission in the report by Jaglal et al. (2009) than any other issue. It should be noted that although readmission rates were significant due to pressure ulcers, when considering the subsequent length of stay often associated with this specific complication, the impact of pressure ulcers are even more consequential (Savic et al. 2000; Middleton et al. 2004).

Cardenas et al. (2004) conducted multivariate logistic regression on the large US Model Systems dataset and determined that motor FIM™ scores at discharge and the payer were the two most significant predictors of rehospitalization within the first year (i.e., those with lower motor score state or federal funded persons vs those with private insurance were more likely to be hospitalized). Payer, motor FIM™ and race were also noted as predictors of readmission at later points in time. A similar analysis was conducted by 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 outpatient physician visits and ≥50 specialist visits following the initial admission. Odds ratios for individual factors associated with the highest likelihood 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). Charlifue et al. (2004) noted that both the number and
length of rehospitalizations 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.

**Healthcare Utilization**

Similar to that evident with hospital readmissions, it is apparent that persons with SCI utilize other aspects of the healthcare system more frequently than most other persons, especially in the first year following rehabilitation discharge. Three Canadian studies from two separate jurisdictions (i.e., provinces of Alberta and Ontario) determined the rates of physician contacts for persons returning to the community following initial rehabilitation. Guilcher et al. (2010) and Munce et al. (2009) examined the linked results from several province-wide (Ontario) administrative healthcare databases to investigate differences in the number of physician contacts in the first year following rehabilitation associated with etiology (i.e., nontrauma / trauma) or gender respectively. There were no significant differences due to etiology with similar numbers of overall physician visits for those with nontraumatic vs traumatic SCI (31.2 vs 29.7 respectively), however there were differences in the types of physicians seen between the 2 groups (Guilcher et al. 2010). Women with SCI had significantly more physician visits than men in the first year following discharge (37.0 vs 30.0) although they were more likely to visit their family physician, whereas men had significantly more visits to their physiatrist (Munce et al. 2009). Some of the individual factors associated with a greater likelihood of having more physician visits included age, lower function (i.e., lower FIM scores), direct discharge to a chronic care / other rehabilitation facility, urban vs rural residence or the presence of comorbidities / prior (in-hospital) complications (Munce et al. 2009; Guilcher et al. 2010). Dryden et al. (2004) used similar methodologies in another Canadian province (i.e., Alberta) and found a median number of physician contacts of 22.0 in the first year and this declined dramatically to 8.0 visits by year 2 and to 4.0 visits by year 6. In all cases, control subjects identified in the overall health registry and matched by age, gender and geographic region had significantly fewer physician contacts for each year (median = 3.0 visits).

**Conclusions**

*There is level 4 evidence that at least 25% of persons with SCI (moreso in some jurisdictions including the US) may expect a hospital readmission in the first year following discharge from SCI rehabilitation.*

*There is level 4 evidence from three studies that hospital re-admission rates are highest in the first year post injury and then stabilize at a still significantly high rate.*

*There is level 4 evidence from eight studies that urinary problems (UTIs), pressure ulcers, respiratory infections and musculoskeletal problems are consistently among the most frequent causes of hospital readmission among persons with SCI.*

*There is level 4 evidence from three studies that factors such as increased age, lower function / greater severity of injury, prior contact with the health system, funding, rural habitation and being unmarried are associated with a greater chance of a hospital readmission.*

*There is level 3 evidence from 1 study and supported by two level 4 studies that persons with SCI have an increased number of physician contacts as compared to matched controls from the general population, especially moreso in the first year post-injury.*
There is level 3 evidence (with predominately US data) that rehabilitation LOS has become progressively shorter up to the mid-1990s. Only investigators from Israel have published data that supports this contention.

There is level 3 evidence 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 1 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 1 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 evidence based on a single case series that increased therapeutic intensity may not be associated with any functional benefit as measured by the FIM.

There is level 3 evidence that significantly shorter rehabilitation LOS is associated with younger vs older individuals with paraplegia. The same may not be true for those with tetraplegia or for mixed cohorts involving traumatic and nontraumatic SCI.

There is level 3 evidence that age is inversely related to patient’s independence level.

There is level 3 evidence that younger as compared to older individuals are more likely to obtain greater functional benefits during rehabilitation.

There is level 3 evidence 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 nontraumatic SCI. The same may not be true for those with paraplegia.

There is level 4 evidence that those with nontraumatic SCI are more likely to be older, female, have paraplegia and have an incomplete injury as compared to those with traumatic SCI.

There is level 3 evidence that those with nontraumatic SCI have generally reduced rehabilitation LOS, reduced hospital charges but similar discharge destinations as compared to those with traumatic SCI.

9.0 Summary

There is level 3 evidence (with predominately US data) that rehabilitation LOS has become progressively shorter up to the mid-1990s. Only investigators from Israel have published data that supports this contention.

There is level 3 evidence 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 1 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 1 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 evidence based on a single case series that increased therapeutic intensity may not be associated with any functional benefit as measured by the FIM.

There is level 3 evidence that significantly shorter rehabilitation LOS is associated with younger vs older individuals with paraplegia. The same may not be true for those with tetraplegia or for mixed cohorts involving traumatic and nontraumatic SCI.

There is level 3 evidence that age is inversely related to patient’s independence level.

There is level 3 evidence that younger as compared to older individuals are more likely to obtain greater functional benefits during rehabilitation.

There is level 3 evidence 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 nontraumatic SCI. The same may not be true for those with paraplegia.

There is level 4 evidence that those with nontraumatic SCI are more likely to be older, female, have paraplegia and have an incomplete injury as compared to those with traumatic SCI.

There is level 3 evidence that those with nontraumatic SCI have generally reduced rehabilitation LOS, reduced hospital charges but similar discharge destinations as compared to those with traumatic SCI.
There is conflicting level 3 evidence that individuals with nontraumatic SCI have lower FIM efficiencies than those with traumatic SCI, although many studies are comparing persons with different etiologies of nontraumatic SCI.

There is level 3 evidence that individuals with traumatic SCI with or without concomitant TBI have similar LoS and achieve similar FIM motor scores, but associated costs were higher in those with dual diagnosis.

There is level 3 evidence from a single study that there is no difference with respect to gender on discharge destination, rehabilitation LOS and neurological or functional outcomes associated with rehabilitation, although there is conflicting level 4 evidence from individual studies that indicate gender differences for some of these outcomes.

There is level 3 evidence that there is no difference with respect to race (Caucasians vs African-American) on rehabilitation LOS and neurological or functional outcomes associated with rehabilitation that are not otherwise explained by socio-demographic or etiological differences.

Based on several retrospective, case-control studies there is level 3 evidence 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 that individuals cared for in interdisciplinary, specialist acute care SCI units have fewer complications upon entering and during their rehabilitation programs.

There is level 4 evidence that individuals initially cared for in interdisciplinary, specialist acute care SCI units make more efficient functional gains during rehabilitation (i.e., more or faster improvement).

There is level 4 evidence that individuals cared for in interdisciplinary, specialist SCI units have reduced mortality.

Based on several retrospective, case-control studies there is level 3 evidence 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 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 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 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 4 evidence 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 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 that regular and accessible interdisciplinary follow-up can result in achieving functional goals where protocolized SCI care is unavailable.

There is limited Level 1 evidence from a single study that telemedicine videoconferencing as an adjunct to routine follow-up care improves patient satisfaction and may lead to enhanced functional outcomes.

There is level 4 evidence that at least 25% of persons with SCI (more so in some jurisdictions including the US) may expect a hospital readmission in the first year following discharge from SCI rehabilitation.

There is level 4 evidence from three studies that hospital re-admission rates are highest in the first year post injury and then stabilize at a still significantly high rate.

There is level 4 evidence from eight studies that urinary problems (UTIs), pressure ulcers, respiratory infections and musculoskeletal problems are consistently among the most frequent causes of hospital readmission among persons with SCI.

There is level 4 evidence from three studies that factors such as increased age, lower function / greater severity of injury, prior contact with the health system, funding, rural habitation and being unmarried are associated with a greater chance of a hospital readmission.

There is level 3 evidence from 1 study and supported by two level 4 studies that persons with SCI have an increased number of physician contacts as compared to matched controls from the general population, especially more so in the first year post-injury.
### Appendix 1: Studies Describing Rehabilitation Outcomes

#### Table 16 Individual Studies Describing SCI Rehabilitation Outcomes

<table>
<thead>
<tr>
<th>Author Year</th>
<th>Country</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gupta et al. 2009</td>
<td>India</td>
<td>Case series</td>
<td>N=64</td>
<td><strong>Population:</strong> Mean age = 30.64; Gender: males = 28, females = 36; Level of injury: paraplegia=67.2%, quadriplegia = 32.8%; Duration of illness =7.1±9.2 months. <strong>Treatment:</strong> Admission / discharge data for nontraumatic patients admitted for neurological rehabilitation from June 2005 to January 2008 was analyzed. <strong>Outcome Measures:</strong> Functional (BI) and neurological (AIS) outcomes and complication prevalence collected at admission and discharge.</td>
<td>1. LOS was 55.8±40.9 days (Range 14-193 days). 2. BI scores showed significant functional recovery (p=0.000). 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 urinary tract infection (50.0%), spasticity (35.9%), urinary incontinence (31.3%) and pressure ulcer (25.0%).</td>
</tr>
<tr>
<td>Gupta et al. 2008</td>
<td>India</td>
<td>Case series</td>
<td>N=76</td>
<td><strong>Population:</strong> Traumatic (n=38): Mean age = 32.86yrs; Gender: males = 34, females = 4; Nontraumatic (n=38): Mean age = 31.10; Gender: males = 16, females = 22 <strong>Treatment:</strong> Admission / discharge data from all surviving nontraumatic and traumatic spinal cord lesion patients in a neurological rehabilitation facility was assessed over a 2 year period. <strong>Outcome Measures:</strong> LOS, BI, AIS collected at admission and discharge.</td>
<td>1. The traumatic group had significantly more males than females (p&lt;0.05) and was not significantly different in age, marriage, education or socioeconomic factors. 2. LOS was 66.0±47.7 days (trauma) and 60.7±45.7 which was not significantly different between groups. 3. Both trauma and nontrauma patients showed significant gains in function with BI increasing significantly from admission to discharge (p&lt;0.05) although there was no between group differences. 4. AIS scores showed nontraumatic 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).</td>
</tr>
<tr>
<td>Moslavac et al. 2008</td>
<td>Croatia</td>
<td>D&amp;B=14</td>
<td>Case series</td>
<td>N=154</td>
<td><strong>Population:</strong> Level of injury: paraplegia=93, tetraplegia=61; Severity of injury: AIS A=76, B=13, C=33, D=19, E=13 <strong>Treatment:</strong> Records of SCI patients involved in a road accident admitted to the national Spinal Unit</td>
</tr>
<tr>
<td>Author Year</td>
<td>Country</td>
<td>Research Design</td>
<td>Total Sample Size</td>
<td>Methods</td>
<td>Outcome</td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
<td>-----------------</td>
<td>-------------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>DeVivo 2007</td>
<td>USA</td>
<td>Case series</td>
<td>N=24,332</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Population: 1973-1981: Mean age = 28.8yrs; Gender: male=81.6%; Level of injury: C1-C4=15.3%, C5-C8=38.1%, T1-S5=45.6%; AIS A=52%, B=9.9%, C=8.4%, D=28.7%, E=1%; 2002-2006: Mean age = 38.3yrs; Gender: male=77.6%; Level of injury: C1-C4=23.1%, C5-C8=32.4%, T1-S5=43.9%; AIS A=43.2, B=11.8%, C=14.8%, D=29.6%, E=0.6%

Treatment: Patients with traumatic SCI in the SCI model care systems in the United States between 1973 and 2006 were followed.

Outcome Measures: LOS, FIM, AIS. All analyzed for admission, discharge, and 5 years post-discharge.

1. Length of stay decreased by 11.4 days in acute care and 62.6 days in rehabilitation (p<0.01).
2. A decrease was seen in the mean days re-hospitalized in 1992-1996, but has increased slightly since (p<0.01).
3. 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).
4. FIM motor scores at admission & discharge decreased significantly during the past 20 years (P<0.0001).
5. For 2002-2006, among injuries that were initially neurologically complete, 15.1% became incomplete by discharge. Among AIS B injuries, 45.2% improved at least one grade, whereas 54.3% of AIS C injuries improved to at least AIS D injuries. This suggests some gains in the likelihood of neurologic improvement over the past 30 years.
6. Mean age increased significantly from 1973-1981 to 2002-2006 (28.8yrs to 38.3yrs, p<0.0001).
7. A significant decline in the number of male patients was seen from 81.6 to 77.6% (p<0.0001).
8. Injuries due to falls increased steadily over time (p<0.0001).
9. Increase in average education level was seen by 2002 (p<0.0001).
10. Mean acute care costs increased by $127,102 (p<0.01) and $8948 per day (p<0.01).
11. Mean rehabilitation charges decreased by $4,725 but per day
<table>
<thead>
<tr>
<th>Author Year</th>
<th>Country</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chan &amp; Chan 2005</td>
<td>Hong Kong, China</td>
<td>Case Series</td>
<td>Initial N=33 Final N=33</td>
<td>Population: Traumatic SCI: Mean age = 48.4 yrs; Gender: males = 30, females = 3; Level of injury: paraplegia = 9, tetraplegia = 24. Treatment: No treatment per se, but various outcomes associated with inpatient rehabilitation. Outcome Measures: FIM, LOS. All collected at admission, discharge, and 1 and 3 months post-discharge.</td>
<td>1. 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. 2. All groups showed increases in FIM motor scores from admission to discharge but these were only significant for tetraplegia AIS D (p&lt;0.05) given small group sizes. 3. Little change in cognitive FIM was seen between admission and discharge due to ceiling effects. 4. FIM motor scores generally continued to increase at 1 and 3 months post-injury although small N sizes and missed follow-ups precluded statistical significance. 5. LOS was generally longer for tetraplegia (low level was significant, p&lt;0.0005) although there were low N’s for each group (varied from 52.0-215.9 days).</td>
</tr>
<tr>
<td>Ronen et al. 2004</td>
<td>Israel</td>
<td>Case series</td>
<td>N=1401</td>
<td>Population: TSCL (250): Mean age = 34.5 yrs; Gender: males:female = 3.3:1; Level of injury: cervical = 37%, thoracic = 32%, lumbosacral =31%; Severity of injury: Frankel grade A/B = 46%, C = 40%, D = 14%; NTSCCL (1117): Mean age = 47.1 yrs; Gender: male:female = 1.2:1; Level of injury: cervical = 32%, thoracic = 44%; lumbosacral = 24%; Severity of injury: Frankel grade A/B = 16%, C = 45%, D = 39%. Treatment: SCL patient data was retrospectively reviewed. Outcome Measures: LOS, mortality risk, SCIM-II gain.</td>
<td>1. Mean LOS for TSCL was more than double of NTSCCL patients (239 vs 106 days, p&lt;0.001). 2. LOS was significantly associated with: • SCL etiology • SCL severity, with LOS being longer for patients with Frankel grades A, B, and C (p&lt;0.001). • Decade of admission to rehabilitation, with reduction over the last few decades, p&lt;0.001. 3. LOS was not significantly associated with: • Gender (p&lt;0.02). • SCL level (p=0.092). • Age (p=0.08). 4. In patients with NTSCCL there was a significant increase in mortality risk for each additional day of hospitalization (p&lt;0.001). 5. SCIM-II gain and relative SCIM II gain were positively correlated with LOS (p&lt;0.001).</td>
</tr>
<tr>
<td>Chung et al. 2003</td>
<td>Taiwan</td>
<td>Popul</td>
<td>Population: Mean age = 43 yrs; Gender: males = 51, females = 17.</td>
<td>1. Performance on ADLs was the only direct predictor of LOS, while increase of $1018 was seen (p&lt;0.01).</td>
<td></td>
</tr>
<tr>
<td>Author Year Country</td>
<td>Research Design</td>
<td>Total Sample Size</td>
<td>Methods</td>
<td>Outcome</td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------</td>
<td>------------------</td>
<td>---------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>Pollard &amp; Apple 2003 USA</td>
<td>Case Series</td>
<td>Initial N=412 Final N=95</td>
<td><strong>Population:</strong> Patient Database (N=412), traumatic, incomplete tetraplegia admitted within 90 days post-injury (N=95). <strong>Treatment:</strong> No treatment per se, but various outcomes associated with inpatient acute care and rehabilitation. Main factors examined were effect of intravenous steroids, early definitive surgery (&lt;24 hours after injury) and early decompression surgery. Mean acute care LOS was 15±16 days and mean rehabilitation LOS was 47±30 days. <strong>Outcome Measures:</strong> Change in sensory score, final sensory score, change in motor score, final motor score. All collected at admission and discharge (also for some at time of injury and 1, 2, 3 years post-injury or the latest anniversary).</td>
<td>1. 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. 2. Younger individuals (&lt;18) had more improvement in motor scores but not sensory scores than older people (p=0.002). 3. 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). 4. There was no effect of methylprednisolone (MP) administration, early anterior decompression, decompression of stenosis without fracture, gender or race. Those with MP administration did have greater improvements in sensory scores (p=0.027) although there was no difference in the final sensory score for those with and without MP.</td>
<td></td>
</tr>
<tr>
<td>Pagliaccu et al. 2003 Italy</td>
<td>Case Series</td>
<td>Initial N=684 Final N=684</td>
<td><strong>Population:</strong> Multi-centre Italian prospective survey, Traumatic SCI, Gender: 80.1 % males, Age: mean=38.5, median=33.7 (11-94) years, Tetraplegia, Paraplegia, AIS A-E. <strong>Treatment:</strong> No treatment per se, but various outcomes associated with inpatient acute care and rehabilitation. 7 participating centers provided integrated acute and rehabilitation care while 30 centres provided only</td>
<td>1. Neurological improvement was associated with AIS B and C, shorter LOS, greater chance of seeing neurological improvement with earlier admission (3-30 days vs &gt; 30 days, p&lt;0.001). Presence of complications (especially pressure sores) on admission or during stay reduced likelihood of attaining neurological improvement. Multivariate analysis also showed incompleteness was</td>
<td></td>
</tr>
<tr>
<td>Observational</td>
<td>Initial N=68 Final N=68</td>
<td>Treatment: No treatment per se, but LOS is modeled (predicted) by various measures associated with inpatient rehabilitation. <strong>Outcome Measures:</strong> LOS and various predictor variables (age, gender, ADLs, subjective well-being and cognitive-social skills). Predictor variables collected at admission to inpatient rehabilitation.</td>
<td>subjective well-being and gender affect LOS indirectly through other predictors (subjective well-being via ADLs). 2. LOS increases as ADL performance deteriorates. Clients with good subjective well-being scores will tend to perform better on ADLs, resulting in shorter LOS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Author Year</td>
<td>Country</td>
<td>Research Design</td>
<td>Population:</td>
<td>Treatment:</td>
<td>Methods:</td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
<td>-----------------</td>
<td>-------------</td>
<td>------------</td>
<td>---------</td>
</tr>
<tr>
<td>Tooth et al. 2003</td>
<td>Australia</td>
<td>Case Series- Initial N=587 Final N=167</td>
<td>Traumatic SCI, 77.8% males, Age=34.9±17.1 (13-90) years, incomplete tetraplegia (47.9%), complete tetraplegia (13.2%), incomplete paraplegia (16.2%) and complete paraplegia (22.8%).</td>
<td>No treatment per se, but various outcomes associated with admission to an integrated unit for acute and rehabilitation care. Sub-analysis focused on effects of level of impairment as</td>
<td>rehabilitation care. <strong>Outcome Measures:</strong> AIS (neurological status), various complication incidence, LOS, Bladder management method, Bowel status, Feeling of dependency, Discharge destination. Collected at admission and discharge.</td>
</tr>
</tbody>
</table>

1. Mean acute care LOS was 45.6±35.9 days and median rehabilitation LOS was 83 days (3-317 days) (Mean = 99.6 days).
2. Rehabilitation LOS was significantly longer for those with complete tetraplegia as compared to those with incomplete tetraplegia or incomplete/complete paraplegia (p<0.001).
3. Mean total FIM increased from 68.7 (admission) to 102.2 independently predictive of improvement.
2. Average rehabilitation LOS was 135.5 days (median 122 days). Longer LOS was associated with younger age, longer time from injury to admission, previous place of management, surgical management, tetraplegia, completeness, presence of complications at admission or during stay and marginally, admission to an integrated (vs Rehab only) centre.
3. 81.9% of people were discharged to home (private residence). Increased likelihood of being discharged home were seen with paraplegia, bladder and bowel autonomy, absence of pressure sore on discharge, longer Length of Stay and marginally, younger age.
4. Bladder autonomy was attained in 65% of patients. Reduced likelihood of achieving bladder autonomy was seen with tetraplegia, completeness, at least 1 complication, longer time from injury to admission, longer LOS.
5. Reduced likelihood of feelings of dependency was associated with paraplegia, neurological improvement, discharge home, bladder and bowel autonomy, no pressure sores and incompleteness. Multivariate analysis also showed a shorter time between injury and admission was independently predictive of lower feelings of dependency.
<table>
<thead>
<tr>
<th>Author Year</th>
<th>Country</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sumida et al. 2001</td>
<td>Japan</td>
<td>Case Control</td>
<td>Initial N=139; Final N =123</td>
<td>measured by neurological status and by the Australian National Sub-acute and Non-acute Patient Classification System (AN-SNAP) on Length of Stay. <strong>Outcome Measures:</strong> LOS, FIM (motor, cognitive and total), Discharge destination. All collected at admission and discharge.</td>
<td>(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 with significant differences found between the various neurological categories. Those with complete tetraplegia had the least change in FIM scores. 4. 75.4% were discharged to a community dwelling and 10.8% to a transitional rehabilitation program. Those with greater impairment were less likely to be discharged to a community setting (i.e., 92.6% with incomplete paraplegia vs 72.7% with complete tetraplegia). 5. AN-SNAP-predicted LOS was generally much shorter than actual LOS.</td>
</tr>
</tbody>
</table>

**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 tx per se, comparison of those admitted earlier (< 2 weeks post injury) vs 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 vs 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). |

| Eastwood et al. 1999 | USA | Case Series | Initial N=5,180 Final N=3,904 | measured by neurological status and by the Australian National Sub-acute and Non-acute Patient Classification System (AN-SNAP) on Length of Stay. **Outcome Measures:** LOS, FIM (motor, cognitive and total), Discharge destination. All collected at admission and discharge. | 1. Rehabilitation LOS was reduced from 74.1 days in 1990 to 60.8 days in 1997 (p<0.001). Acute care LOS was 21 days in 1990 and 20 days in 1991. 2. Many variables significantly predicted increases in LOS at p<0.001 level of significance (in descending order): low admission FIM, earlier discharge year, complete tetraplegia, indwelling |

**Population:** Traumatic SCI from US Model Systems database, age categories from <21 to >51, 80.9% males, tetraplegia and paraplegia, incomplete and complete.  
**Treatment:** No treatment per se, but various outcomes associated with inpatient rehabilitation to predict LOS, rehospitalization, residence, days out of residence (QoL) and pressure sores.  
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 vs 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). |
<table>
<thead>
<tr>
<th>Author Year</th>
<th>Country</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morrison &amp; Stanwyck 1999</td>
<td>USA</td>
<td>Case Control</td>
<td>N = 127</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Population:** Acute traumatic SCI: Mean age = 28.81 yrs; Level of injury: paraplegia, tetraplegia, C5-L2; Severity of injury: complete.  
**Treatment:** No treatment per se, but effect of Length of Stay on functional and medical status was examined by comparing those admitted in 1991 vs those in 1995. (LOS was significantly reduced in 1995, p<0.001).  
**Outcome Measures:** FIM (Individual scores for 11 items), Functional motor skills (5 skills, custom), Locomotor skill (5 skills, custom), incidence of medical complications (pressure sores, UTIs, pain), employment status all collected at discharge and 2 month post-discharge.

1. In general, the group with shorter LOS did not differ dramatically from the group with longer LOS. Subjects also spent less time in PT and OT from 1991 to 1995 (p<0.001). 
2. There were higher discharge scores for bowel management, stairs, manual locomotion, rolling supine to prone and rolling side to side for those with longer LOS in paraplegics. No significant differences were seen in tetraplegic patients. (Many results showing no differences not presented). 
3. Post discharge performance skills in those with tetraplegia showed that those with shorter LOS had higher function in the following areas: bathing (p=0.39), bed transfer (p=0.27), and toilet transfer (p=0.047). For those with paraplegia, the shorter LOS group was higher in the following areas: grooming (p<0.011), upper

**Outcome Measures:** Rehabilitation LOS, rehospitalization, residence, days out of residence (QoL), pressure sore incidence and many predictor variables. Collected at admission, discharge and 1 year post-injury. 

3. Individuals initially discharged to a skilled nursing facility were more likely to return home by 1 year if they were young, had higher admission and discharge FIM scores, greater FIM change, if they were able to leave the institution more frequently and more likely to use IC vs indwelling catheter. 
4. Individuals were more likely to be rehospitalized if they had lower discharge FIM scores, complete paraplegia, having an indwelling catheter or using intermittent catheterization and with a shorter rehabilitation Length of Stay. 
5. Predictors of having pressure sores at year 1 were having complete paraplegia, not having incomplete tetraplegia, lower FIM scores and older age.
<table>
<thead>
<tr>
<th>Author Year Country</th>
<th>Research Design</th>
<th>Total Sample Size</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Müslümanoğlu et al. 1997</td>
<td>Turkey</td>
<td>Pre-Post</td>
<td>Initial N=52, Final N=10</td>
<td>body dressing (p=0.003), car transfer (p=0.018) and manual locomotion (p=0.031). 4. The proportion of subjects who reported UTIs, pressure sores and pain was higher in the shorter LOS group.</td>
</tr>
<tr>
<td>DeVivo et al. 1991</td>
<td>USA</td>
<td>Case Series</td>
<td>Initial N=13,763, Final N=13,763</td>
<td>Population: Mean age = 36.4 yrs; Gender: males = 32, females = 20; Level of injury: paraplegia = 19, tetraplegia = 18; Severity of injury: complete = 9, incomplete = 19. Treatment: No treatment per se, but various outcomes associated with inpatient rehabilitation of 93.9 ±44.95 (14-258) days. Outcome Measures: Motor scores, light touch scores and FIM. All collected at admission, discharge, and 1 year post-discharge (N=10 only). 1. Neurological assessments (Motor scores and light touch scores) showed increases from admission to discharge for those with incomplete injuries (p&lt;0.001) but not complete injuries. 2. FIM showed increases from admission to discharge for those with incomplete injuries (p&lt;0.05) and those with complete paraplegia (p&lt;0.05) but not complete tetraplegia. 3. FIM scores (p&lt;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.</td>
</tr>
<tr>
<td>Author Year Country</td>
<td>Research Design</td>
<td>Total Sample Size</td>
<td>Methods</td>
<td>Outcome</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------</td>
<td>-------------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>Roth et al. 1990 USA</td>
<td>Case series</td>
<td>Initial N=81 Final N=81</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Population: Traumatic central cord syndrome: Mean age = 45.5 yrs; Gender: males = 67, females = 14; Level of injury: tetraplegia; Severity of injury: Frankel C, D; Mean time since injury = 29.8 days. Treatment: No treatment per se, but outcomes associated with inpatient rehabilitation. LOS 69.6 ± 39.2 days. Outcome Measures: Modified Barthel Index (MBI) collected at admission and discharge.</td>
<td></td>
<td>to a private residence, 4.0% to nursing homes, 1.5% to other hospitals. Of 1,306 followed 10 years, 98.0% resided in private residences. 6. 51.2% of those with grade 9-11 completed high school within 5 years after injury and 11.6% of those with high school education completed a higher academic degree within 5 years. 7. The proportion of people employed increased from 12.6% 2 years after injury to 38.3% 12 years after injury. 8. In the second year post-discharge, 35.7% of people were rehospitalized and this declined to 25% at 12 years. 9. Overall survival rate was 76.9%. During the first 12 years after injury, cumulative survival rate increased to 88% of what it would be in the absence of injury. Highest causes of death were pneumonia, pulmonary embolism and septicemia (due to pressure sores, respiratory infections or UTIs).</td>
<td></td>
</tr>
<tr>
<td>Yarkony et al. 1990 USA</td>
<td>Case Series</td>
<td>N=1,382</td>
<td>Population: Traumatic SCI: Gender: males = 83%, female = 17%; Level and severity of injury: incomplete tetraplegia = 30%,</td>
<td>Rehabilitation Length of Stay decreased over study period from 56.5 days in 1974 to 68.1 days in 1986 (82.8 for tetraplegia and</td>
</tr>
<tr>
<td>Author Year</td>
<td>Country</td>
<td>Research Design</td>
<td>Total Sample Size</td>
<td>Methods</td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
<td>----------------</td>
<td>------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Yarkony et al. 1990</td>
<td>USA</td>
<td>Case series</td>
<td>Initial N=184 Final N=184</td>
<td>Population: Traumatic Complete Thoracic SCI: Mean age = 27.2 yrs; Gender: males = 81%, females = 19%; Mean time since injury = 46 days. Treatment: No treatment per se, but outcomes presented associated with inpatient rehabilitation. Length of stay 84 days. Outcome Measures: Modified Barthel Index (MBI) collected at admission and discharge.</td>
</tr>
<tr>
<td>Yarkony et al. 1987</td>
<td>USA</td>
<td>Case series</td>
<td>Initial N=711 Final N=711</td>
<td>Population: Traumatic SCI: Mean age = 28.2 yrs; Gender: males = 82%, females = 18%; Level of injury: paraplegia = 45%, tetraplegia = 55%; Severity of injury: complete, incomplete; Mean time since injury = 28.8 days. Treatment: No treatment per se, but outcomes associated with inpatient rehabilitation. LOS 69.6 ± 39.2 days. Outcome Measures: LOS, Modified Barthel Index (MBI) collected at admission and discharge.</td>
</tr>
<tr>
<td>Burke et al. 1985</td>
<td>Australia</td>
<td></td>
<td></td>
<td>Population: Gender: males = 209, females = 53; Level of injury:</td>
</tr>
<tr>
<td>Author Year</td>
<td>Country</td>
<td>Research Design</td>
<td>Total Sample Size</td>
<td>Methods</td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
<td>-----------------</td>
<td>------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Case Series</td>
<td>Initial N=352</td>
<td>Final N=262</td>
<td></td>
<td>paraplegia, tetraplegia; Severity of injury: Frankel A-E.</td>
</tr>
<tr>
<td></td>
<td>Treatment: No treatment per se, but various outcomes associated with admission to an integrated unit for acute and rehabilitation care.</td>
<td>2. Of those discharged “normally”, Total hospital LOS ranged from 113 (D, E paraplegia) to 282 (A, B tetraplegia) days with completeness having a greater impact on stay than level.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outcome Measures: Frankel scale, Mortality, Urinary tract management and pathogen status, physical independence (Walking, Dressing, Transfers, Driving, Finances), Total hospital LOS. All collected at admission and discharge.</td>
<td>3. 69.1% of people were discharged catheter-free with 14.9% (26.4% of females and 12.0% of males) discharged with an indwelling catheter. 77.9% were discharged with sterile urine.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woolsey, 1985</td>
<td>USA</td>
<td>Case Series</td>
<td>Initial N=100</td>
<td>Final N=96</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Population: Traumatic SCI in VA SCI Service: Gender: males; Level of injury: paraplegia = 38, tetraplegia = 62; Severity of injury: complete = 73, incomplete = 27; Time since injury: &lt; 1 month = 59, &lt; 2 months = 28, &gt; 2 months = 13. Treatment: No treatment per se, but various outcomes associated with inpatient rehabilitation. LOS = 3.3 (paraplegia) and 5.5 months (tetraplegia). Outcome Measures: Attainment of functional goals by discharge or in some cases later follow-up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6. 40% with complete tetraplegia could drive with hand controls at discharge.</td>
</tr>
</tbody>
</table>

1. The higher the injury, the more likely an individual did not meet goals of self-care and mobility. |
2. 83/100 were discharged to their homes, 13 to nursing homes. |

Note: ADLs=Activities of Daily Living; AIS=ASIA Impairment Scale; BI=Barthel Index; FIM=Functional Independence Measure; LOS=Length of Stay; NTSCL=Non Traumatic Spinal Cord Lesions; QoL=Quality of Life; SCIM-II=Spinal Cord Independence Measure II; UTIs=Urinary Tract Infections
References


