3. Efficacy and Models of Care Following an Acquired Brain Injury

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Abbreviations

ABI	Acquired Brain Injury
BTF	Brain Trauma Foundation
FIM	Functional Independence Measure
GCS	Glasgow Coma Scale
GOS	Glasgow Outcome Scale
ICP	Intracranial Pressure
ICU	Intensive Care Unit
LOS	Length of Stay
PCT	Prospective Controlled Trial
RCT	Randomized Controlled Trial
TBI	Traumatic Brain Injury

Key Points

Implementation of TBI protocols based on guidelines from the American Association of Neurologic Surgeons, the Brain Trauma Foundation, or generally accepted best practices may improve mortality and patient outcomes in patients with TBI; however this may only be the case if protocol compliance is sufficiently high.

Implementation of a neurocritical care consult service, introduction of mutual neurocritical care/neurosurgery rounds, introduction of a TBI protocol, and clustering of patients with a neurocritical care diagnosis in the same unit may improve hospital mortality post TBI.

Formalized early intervention programs can reduce coma duration and hospital length of stay, and improve cognitive levels at discharge and rate of discharges to home, in patients with TBI.

Greater resource availability and more aggressive care may improve mortality in patients with severe TBI.

Functionally-based streamed models of inpatient rehabilitation may improve targeted deficits more than all-encompassing traditional inpatient rehabilitation methods in patients with TBI.

Compared to a single-discipline approach, a coordinated, multidisciplinary approach to inpatient rehabilitation may result in functional improvements that are sustained for longer in patients with TBI

Increasing inpatient rehabilitation intensity can reduce hospital length of stay post ABI.

Increasing inpatient rehabilitation intensity, compared to standard therapy, can improve Glasgow Outcome Scale scores and functional outcomes post ABI in the short term.

The efficacy of increasing inpatient rehabilitation intensity post ABI can change based on the rehabilitation institution and available resources.

Inpatient therapy intensity predicts motor functioning post ABI at discharge.
Early inpatient rehabilitation is associated with better outcomes in individuals post ABI.
Inpatient rehabilitation in the chronic phase of ABI can still yield meaningful results.
Earlier outpatient rehabilitation is associated with better outcomes post ABI.

More intensive outpatient rehabilitation is associated with better functional outcomes post ABI. However, this may not be the case if intensity is high enough to interfere with a patient's ability to perform day to day responsibilities.

Compared to individuals with an ABI who are treated in the community, those treated at an outpatient clinic may be less dependent on support from others, more independent in mobility, display fewer inappropriate social behaviours, and have less difficulty with motor speech.

High-level involvement in neurorehabilitation goal setting may result in a greater number of attained goals being maintained at follow-up (two months) in individuals with an ABI.
Outpatient care provided at a residential treatment center may improve motor and cognitive function to a greater extent than when care is provided at a nursing facility or at home in individuals with *a* TBI.

Individualized and group vocational rehabilitation programs can improve goal-specific performance and behavioural competency/psychological well-being in individuals post ABI, respectively.

Combining specialized vocational rehabilitation services with a community reintegration outpatient group intervention or comprehensive day treatment may not improve community based employment compared to specialized vocational rehabilitation alone in individuals with an ABI.

Although continuity of care has been shown to be beneficial in optimizing recovery, there is insufficient evidence to draw conclusions regarding the ideal structure of a complete model of ABI care. Further research is required in determining the ideal structure of a complete model of ABI care.

3. Efficacy and Models of Care Following an Acquired Brain Injury

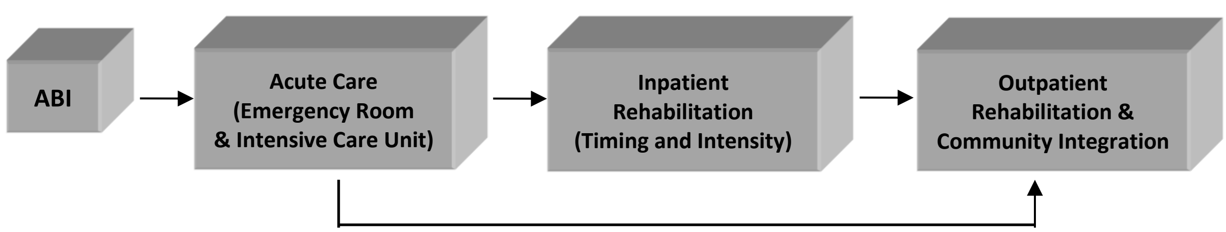
3.1 Introduction

Acquired brain injury (ABI) presents unique challenges that make rehabilitation difficult to standardize. The development of best-practice principles has been hindered by limited access to adequate sample sizes and appropriate comparison groups in patients with ABI within a clinical, rehabilitation environment (National Institute of Health, 1998). Further, there remains a need for more prospective studies, and a more uniform approach to standardized assessment and outcome measures (New Zealand Guidelines Group, 2006). As a result, a consensus on optimal models of care for patients with ABI has been elusive.

In October of 2007, a workshop was held by the National Institute of Neurological Disorders and Stroke to develop a classification system for Traumatic Brain Injury (TBI) designed to direct therapeutic interventions (Saatman et al., 2008). Traditional classification systems have been problematic given the diversity of brain injury needs. This international group of experts emphasized that this work only began to scratch the surface in understanding brain injury care. Nevertheless, a model of the pathway that patients should follow has evolved.

Generally, patients with ABI receive, in order, pre-hospital care, acute care (with neurosurgical intervention if necessary), Emergency Room visit, Intensive Care Unit (ICU) management, inpatient rehabilitation, and are then discharged to the community with varying levels of support (Khan et al., 2002). Additional components of this pathway may include cognitive and behavioural rehabilitation programs, community living opportunities, rehabilitation services in the home, care management, and prevention initiatives (Zygun et al., 2005). Despite effective triage programs, best evidence-based protocols, and progress in the management of secondary complications of severe TBI, significant regional differences in practice exist (Zygun et al., 2005). The typical progression of ABI management is depicted in Figure 1; this figure will be replicated throughout the document as the various stages are explained in more detail.

Figure 1: A schematic depiction of the progression of ABI management.



Internationally, rehabilitation care of patients with brain injury is extremely diverse. Care is dictated by local health care policy, local culture, and resource availability. This in turn has made development of internationally applicable systems challenging. In 1965, the World Federation of Neurosurgical Societies formed an “ad hoc” Committee on Head Injuries which was followed by the formation of the Committee of Neuro-traumatology in 1977 (Teasdale et al., 1997). This provided one of the first published international discussions of brain trauma care. The formation of the International Brain Injury Association in 1993 and the International Association for the Study of Brain Injury in 1998 continued to expand opportunities for the sharing of information (International Brain Injury Association, 2008). In 1995, the Brain Trauma Foundation (BTF) developed the first Guidelines for the Management of Severe TBI (Carney, 2007); these guidelines have since be revised. These guidelines are maintained in conjunction with the American Association of Neurological Surgeons and the Congress of Neurological Surgeons and other stakeholders, such as the European Brain Injury Consortium. Since their inception, countries as diverse as Italy, Mexico, Ireland, and Japan have adapted BTF guidelines to suit local needs (Citerio et al., 2003; Espinosa-Aguilar et al., 2008; Matta & Menon, 1996; Shigemori & Tokutomi, 2002). The World Health Organization has also expanded its focus to assess the need for effective global rehabilitation programs. It has been estimated that over 80% of the world's people with disabilities live in low to middle income countries and only 2% have access to rehabilitation services (Hyder et al., 2007). This is especially disturbing when we consider that the highest rates of TBI due to road traffic incidents are in the Latin American and Caribbean regions, with rates in Sub-Saharan Africa not far behind (Hyder et al., 2007). Other countries such as the United States, have seen relatively stable rates in TBI associated deaths despite education and prevention (Center for Disease Control and Prevention, 2018). From 2001 to 2010, rates of TBIs among males has only decreased from 27.8 per 100 000, to 25.4 per 100 000, meaning the number of individuals requiring access to rehabilitation services remains the same.

One of the most comprehensive national Brain Injury systems has evolved in the United States (US). In 1978 the National Institute on Disability and Health Research (now the National Institute on Disability and Rehabilitation Research) provided funding to New York University's Rusk Center and the Santa Clara Valley Medical Center (San Jose, California) to develop a model of dedicated, interdisciplinary, acute inpatient rehabilitation, coupled with post-acute rehabilitation intervention and cognitive and behavioural approaches (Cope et al., 2005). By August 2004, ABI care in the US included 123 accredited hospitals, 9 skilled nursing facilities (acute inpatient rehabilitation), 153 outpatient programs, 51 home and community programs, 212 long-term residential programs, 231 residential programs and 86 vocational programs (Cope et al., 2005). While there is no one body which oversees brain injury rehabilitation specifically, several organizations have been developed in an attempt to improve the cohesion of the system. Some of the more influential organizations include the Brain Injury Association of America which was established in 1980 and currently works with 40 state run Brain Injury affiliates (Brain Injury Association of America, 2015) to provide community services to individuals with brain injuries. The National Association of State Head Injury Administrators developed in 1990 as a forum to provide information to State governments and policy makers regarding brain injury (National Association of State Head Injury Administrators, 2008), while the Center for Disease Control collects epidemiological information and sponsors research through the Public Health Injury Surveillance and Prevention Program (Centers for Disease Control, 2008). Finally, the Traumatic Brain Injury Model Systems of Care was developed in 1997 as a prospective, longitudinal multi-center study to assess rehabilitation of patients through a coordinated system of acute care and inpatient rehabilitation with a 15 year follow-up (National Data and Statistical Center, 2008). Although these four organizations and others like them work together to provide guidance regarding brain injury care, ultimately decisions are still left to individual institutions and their clinicians, resulting in regional differences in care.

In Canada, brain injury rehabilitation has steadily developed in a similar way to the American system. During the 1980's and 90's, Brain Injury rehabilitation evolved as a specialization of rehabilitation medicine. Rehabilitation hospitals work within provincial health care systems and as a result some provinces, particularly the more scarcely populated ones, have more limited ABI rehabilitation. Moreover, within provinces there is often a disparity in services between larger urban centers and smaller rural areas. While access to care is universally available, private services can be utilized by those with private funding (Cullen, 2007). Reid-Arndt et al. (2010) explain that whilst patients have greatly benefitted under the Rehabilitation Act after the passing of the TBI Act in 1996, community-based interventions, employment services, and independent living programs continue to require additional funding and support.

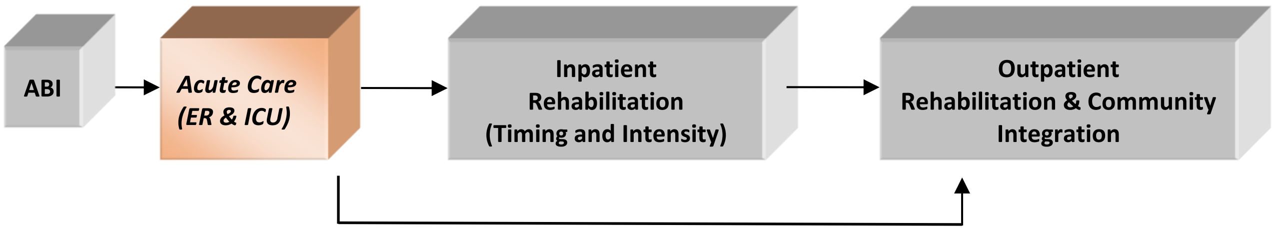
In 2003, the Brain Injury Association of Canada was established to provide a national forum for sharing brain injury information. Currently, only the territories lack a territorial level brain injury association (Brain Injury Association of Canada, 2015). In an attempt to standardize care, Accreditation Canada, a not-for-profit organization, assesses health care institutions in Canada for quality of care and specifically includes brain injury services (Accreditation Canada, 2008). The Canadian Institute for Health Information was established by National, Provincial, and Territorial governments to collect and disseminate health information including information regarding rehabilitation facilities. Rehabilitation information is drawn from the National Rehabilitation Reporting System with 99 facilities across nine provinces submitting data (Canadian Institute for Health Information, 2014). A separate database has also been established at the Toronto Rehabilitation Institute, which is modeled after the American Model systems. The Canadian database was expanded in 2002 to uniquely include individuals with non-traumatic brain injuries as well, which differs from the American system (Cullen, 2007).

Europe presents some unique cultural and political challenges in brain injury. The European Brain Injury Society was formed in 1989 and now has 181 institutional members from all nations in the European Union, as well as Switzerland (European Brain Injury Society, 2015). The European Brain Injury Consortium was formed in 1994, which *"… reflected the realization that numbers of patients required in the design of definitive Phase III studies of severe head injury demanded European-wide recruitment"* (p.798) (Teasdale et al., 1997). While nations were encouraged to continue to develop their own strategies, value was placed on international collaboration. In 1997 the European Brain Injury Consortium developed guidelines for management of severe head injury in adults to attempt to provide some clarity and standardization in brain injury care (Maas et al., 1997). With similar collaborative goals, the European Brain Council was formed in 2002 in Brussels to attempt to coordinate research in the area of brain disease, including brain injury (Olesen & Freund, 2006). Despite these attempts at standardization, national models of ABI care are still dictated by regional health care policies.

March et al. (2013) reviewed the National Mental Health Plan and reported that ABI was not referred to or explicitly acknowledged and that ABI service providers were not incorporated into future target partnerships. Given the nature of ABI and its comorbidities with mental health concerns, March et al. (2013) argue that this absence of acknowledgement hinders dual-diagnosis care and that a collaborated approach with stakeholders will help provide leadership in addressing this issue.

With a global perspective in mind, this module presents a broad analysis of the over-riding systems of care in ABI management. Papers were considered for analysis if they focused on a generalized system of care. Since the aim of this module is to compare different models of rehabilitation and not assess the effectiveness of individual rehabilitation strategies by themselves, only papers that compare at least two distinct rehabilitation groups were included. These could include separate hospitals, separate treatment groups within one center, or comparisons between patients in the same center before and after systemic changes.

3.2 Acute Management and Implementation of Care



The most severe consequences of an ABI are often not due to the initial trauma itself. Secondary brain injury can result in edema, ischemia, elevated intracranial pressure, and inadequate cerebral perfusion pressure, as well as a cellular cascade resulting in calcium imbalances, excitatory amino acid release, and free radical production; all of which can lead to cell death (Zasler et al., 2007). For this reason, the speed and intensity with which patients are cared for is of the utmost importance. Assessments of how to acutely treat patients with ABI generally fall into one of four categories: pre-hospital care, hospital facility type, adherence to acute care guidelines, and discharge destination. Each of these areas presents a unique challenge. Module 16 of this evidence-based review reports the current evidence for acute treatment of ABI. Here we have attempted to highlight concerns and elucidate attempts being made to improve the current system of care with reference to the application and efficacy of treatment protocols and guidelines, and by comparing models of care across different institutions.

Pre-hospital care can be the difference between life and death. The time from injury to intervention is perhaps the most obvious component of pre-hospital care but debate has also arisen regarding the types of treatments that are suitable prior to hospital arrival. In 2000, the BTF released guidelines for pre-hospital management of patients with ABI. An Emergency Medical Service task force developed a consensus based algorithm (Gabriel et al., 2002). The guidelines were then updated in 2007 (Badjatia et al., 2007). Nevertheless, the variability in the way in which care is delivered in the US is still fairly unknown (Bulger et al., 2007). This has also been shown to be true of other countries that have begun to examine protocols for out-of-hospital care (Baethmann et al., 1999; Harrington et al., 2005). Research has been conducted regarding the efficiency of transfer and access to trauma centers in general (Bulger et al., 2007) but little to no research has been performed specifically for brain Injury.

The final stage of acute care involves the transition to post-acute care. Once patients are medically stable they are transferred to one of three places: home, long term care, or a rehabilitation unit. Rehabilitation units for patients with ABI can consist of hospital-based inpatient rehabilitation centers or specialized rehabilitation units that often focus on behavioural issues. One study has shown that approximately 85% of patients are transferred to inpatient rehabilitation within 1 year of ABI (Godbolt et al., 2015). How and by whom this decision is made may greatly affect the type of care that is received by patients. Several factors, such as availability of rehabilitation spaces, the patient's support needs, and the patient's financial situation may play a role in this decision. In the US, Medicaid patients were 68% and Health Maintenance Organization patients were 23% more likely to be discharged to a skilled nursing facility than those on a fee-for-service plan (Chan et al., 2001). In Canada, patients injured in a motor vehicle accident were 1.6 times more likely to be discharged home with support services than those who were injured in a fall (Kim et al., 2006). The standardization of care across multiple institutions helps to ensure that each individual is receiving the best available level of care, and that it is being applied in the most effective manner.

3.2.1 Implementation of Guidelines

As mentioned earlier, guidelines have been established by organizations such as the BTF and the European Brain Injury Consortium to standardize treatment and to aid in the dissemination of information. Audits of guideline implementation can help to ensure that a proper level of care is provided in all types of medical centers. Hesdorffer and Ghajar (2007) demonstrated that there was an increasing trend in guideline adherence with nurses and Intensive Care Unit trauma coordinators. This study showed that guideline adherence improved from 17% to 44.7% from 2000-2006. A study by Griesdale et al. (2015) revealed that adherence to BTF guidelines regarding cerebral perfusion pressure was low with recommended pressure ranges occurring only 31.6% of the time. In addition, Talving et al. (2013) also reported that compliance of BTF guidelines for monitoring intracranial pressure (ICP) was at 46.8%, resulting in signficantly higher mortality and brain herniation among patients not receiving ICP monitoring (Peep Talving et al., 2013). Despite these figures, Shafi et al. (2014) revealed a mean compliance rate of 73% to the BTF guidelines, with 3 of 11 level-1 trauma centres achieving rates of over 80%, thus indicating improvements of clinicians and health professionals transitioning into new methods of practice. In the US alone, it is estimated that a modest improvement to 50% adherence of BTF guidelines from 33% would result in 989 lives saved annually (Faul et al., 2007). Adherence to guidelines is a continuous process, and has a direct impact on patient care. This section summarizes the available evidence evaluating the effect of guideline/protocol implementation on patient outcomes in ABI.

Table 3.1 Guideline Implementation for Acute Management Post ABI

Author/Year/ Country/ Study Design/N	Methods	Outcomes
Tarapore et al. (2016) The Netherlands Cohort N=832	**Population:** TBI; Gender: Male=654, Female=178; Mean Age=38 yr; GCS: mild (n=178), moderate (n=118), severe (n=466). **Intervention:** A joint-commission-certified TBI program was implemented at San Francisco General Hospital and patient outcomes were compared to historic controls. **Outcome Measure:** Early TBI deaths (<24 hr), mortality at 6 mo.	1. The percentage of early TBI deaths (<24 hr) were 59% lower in the Joint Commission-certified TBI program cohort as compared to the historical control cohort. 2. The percentage of observed deaths 6 mo after the Joint Commission-certified TBI program was instituted was 22% lower as compared to the historical cohort.
Kesinger et al. (2014) USA Case Control N=108	**Population:** TBI; *Pre-Standard Trauma Protocols (STP; n=68):* Mean Age=37.1 yr; Gender: Male=63, Female=5. *Post-STP (n=40):* Mean Age=38.6 yr; Gender: Male=31, Female=9. **Intervention:** Chart reviews were conducted comparing hospital records pre and post implementation of STPs. These protocols were based on best practices and damage control resuscitation (e.g., small volume resuscitation, requiring a physician's presence in intra-hospital transportation of severely injured patients, etc.). **Outcome Measure:** Glasgow Coma Scale (GCS), Medical Interventions, Mortality Rates.	1. In the emergency department, after STPs were implemented, there was an increase in resuscitation with 7.5% hypertonic saline (p=0.014), use of catheters (p=0.015), administration of tetanus vaccinations (p=0.034), and earlier use of blood transfusions (p=0.008). 2. Post STP, hospital mortality decreased from 38% to 18% (p=0.024) and GCS scores improved from a median of 10 to a median of 14 (p=0.034).

Kramer & Zygun (2013) Canada Cohort N=4,097	**Population:** TBI=1604, Anoxic BI=552, Subarachnoid Hemorrhage=449, Intracerebral Hemorrhage= 398, Stroke=444, Central Nervous System Infection=242, Status Epilepticus=605; Gender: Male=2581, Female=1516. **Intervention:** Patient data was extracted from an Intensive Care Unit (ICU) database over four time periods based on when new protocols were developed and introduced. New protocols included: Neurocritical Care Consult Service (September 2003), Temperature Regulation Protocol (September 2004), Mutual Neurocritical Care/Neurosurgery Rounds (July 2005), TBI Protocol (August 2008), and Clustering of Neurocritical Care Patients (June 2010). **Outcome Measure:** Hospital Mortality, Discharge Home Without Support.	1. Hospital mortality improved significantly after implementation of a Neurocritical Care Consult Service (p=0.03; Odds ratio=0.81), Mutual Neurocritical Care/Neurosurgery Rounds (p=0.008; Odds ratio=0.80), TBI Protocol (p=0.04; Odds ratio=0.84), and Clustering of Neurocritical Care Patients (p=0.02; Odds ratio=0.76) and improved non-significantly after implementation of the Temperature Regulation Protocol (p=0.07; Odds ratio=0.85). 2. Discharge without home support improved significantly after implementation of a Neurocritical Care Consult Service (p=0.04; Odds ratio=1.27), Mutual Neurocritical Care/Neurosurgery Rounds (p=0.0002; Odds ratio=1.39), Clustering of Neurocritical Care Patients (p=0.01; Odds ratio=1.31), and implementation of the Temperature Regulation Protocol (p=0.0009; Odds ratio=1.38), and improved non-significantly after TBI Protocol implementation (p=0.06; Odds ratio=1.17).
Myburgh et al. (2008) Australia/NZ Cohort N=635	**Population:** TBI; Mean Age=41.6 yr; Gender: Male=471, Female=164; Severity: Mild=159, Moderate=114, Severe=362. **Intervention:** Data was obtained prospectively for patients cared for after the publication of new Brain Trauma Foundation guidelines, and compared to retrospective control data (pre-guidelines). Follow-up telephone interviews were conducted at 6 mo and 12 mo post-injury. **Outcome Measure:** Glasgow Outcome Scale Extended (GOSE), Mortality.	1. Favourable outcomes on the GOSE were found in 58.8% of all patients, and 48.5% of patients with severe TBI. 2. Mortality was reported in 26.9% of all patients and 35.1% for patients with a severe TBI. 3. Although concordance with guideline management was generally seen; mortality and favorable neurological outcomes were similar to previous studies before the advent of evidence-based guidelines.
Fakhry et al. (2004) USA Case Control N=830	**Population:** TBI; *Group 1 (n=219):* Mean Age=33.8 yr; Gender: Male=161, Female=58; Mean GCS=4. *Group 2 (n=188):* Mean Age=33.9 yr; Gender: Male=133, Female=55; Mean GCS=3.5. *Group 3 (n=423):* Mean Age=35.6 yr; Gender: Male=327, Female=96; Mean GCS=3.5. **Intervention:** Patients were retrospectively divided into 3 groups: Group 1, 1991-1994 (pre-guidelines); Group 2, 1995-1996 (post-guidelines low compliance); and Group 3, 1997-2000 (post-guidelines high compliance). Data was extracted from hospital trauma registries and from chart reviews. **Outcome Measure:** Mortality, length of stay, total charges, Rancho Los Amigos Levels of Cognitive Functioning Scale (RLAS), and Glasgow Outcome Scale (GOS).	1. Significant differences were seen between groups, with group 2 achieving higher GOS scores at discharge (p<0.001), a decrease in length of stay in hospital (p=0.001) and a decrease in total charges per patient (p=0.002). 2. A significant drop in mortality was seen in the Group 3 compared to Group 1 (p=0.047). 3. Appropriate responses on the RLAS significantly improved over time from 43.9% in Group 1, 44% in Group 2 and 56.6% in Group 3 (p=0.004).

Palmer et al. (2001) USA Case Control N=93	**Population:** TBI; *Group 1 (n=37):* Mean Age=41.35 yr; Mean GCS=6.43. *Group 2 (n=56):* Mean Age=38.10 yr; Mean GCS=6.88. **Intervention:** Data was collected from the medical records of patients with TBI treated pre- (group 1) and post- (group 2) guideline implementation. **Outcome Measure:** Glasgow Outcome Score (GOS) and cost.	1. Patients in group 2 were more likely to demonstrate significant gains on GOS ($p<0.005$) compared to group 1. 2. Guideline implementation resulted in a 9.13 times higher odds ratio of good outcome relative to poor outcome or death pre-implementation. 3. Hospital charges increased by $97,000 per patient.
Mackay et al. (1992) USA Case Control N=38	**Population:** TBI; *Group 1 (n=17):* Mean Age=29.1 yr; Gender: Male=12, Female=5; Mean GCS=5.18. *Group 2 (n=21):* Mean Age=30 yr; Gender: Male=19, Female=2; Mean GCS=5.80. **Treatment:** Chart reviews were completed on patients treated in hospital. Patients in Group 1 received a formalized early intervention program and were compared with patients in Group 2 who were treated at hospitals without a formalized early intervention program. **Outcome Measure:** Length of coma, length of stay, Rancho Los Amigos Scale of Cognitive Functioning and Injury Severity Score.	1. Patients in Group 1 experienced shorter comas ($p=0.033$), lengths of stay ($p=0.026$) and had a greater likelihood of being discharged to home (94% versus 57%). 2. Patients in Group 1 demonstrated significantly greater functional improvements at discharge in cognitive/language levels ($p=0.018$), motor/physical abilities ($p=0.032$) and perceptual/sensory skills ($p=0.025$) compared with Group 2.

Discussion

A number of studies have investigated the effect of the implementation of protocols incorporating evidence-based guidelines. Kesinger et al. (2014) implemented a Standard Trauma Protocol (STP) at a level 1 trauma center in Colombia and compared outcomes pre- and post-guideline implementation. After STP implementation, hospital mortality decreased by 20%, and median CGS scores at discharge improved from 10 to 14. In another study, Palmer et al. (2001) measured the impact of a protocol based on the American Association of Neurologic Surgeons (AANS) traumatic brain injury guidelines in a community hospital. Patients had 9.13 times higher odds ratio of good outcomes relative to the odds of poor outcomes or death in the post-protocol group versus the pre-protocol group. Hospital charges did increase by $97,000 per patient, however, the authors claim this was justified by the significant improvements in patient outcomes. In southern Alberta, Kramer & Zgun (2013) conducted a cohort study of 4,097 subjects over a more than 11-year period to compare patient outcomes before and after four new protocols were introduced. Hospital mortality improved after implementation of a neurocritical care consult service in 2003, introduction of mutual neurocritical care/neurosurgery rounds in 2005, introduction of a TBI protocol in 2008, and clustering of patients with a neurocritical care diagnosis within a larger unit in 2010. Trends also show improvement in hospital mortality after implementation of the temperature regulation protocol in 2004.

While the implementation of protocols has been shown to improve patient outcomes in a number of studies, adherence to protocols is also an important factor to consider. Three studies consider both implementation and concordance with protocols in TBI care. In a cohort study, Myburgh et al. (2008) prospectively recorded data for patients cared for after the publication of the 1996 BTF guideline, and compared them to patients treated pre-guidelines. Despite guideline publication, mortality and favorable neurological outcomes remained similar pre- and post-publication. In another study, while concordance with the guidelines was evident for measures such as thromboprophylaxis and head elevation, ICP monitoring was used in only 44.5% of patients with severe TBI, indicating that guideline adherence was lacking. Tarapore et al. (2016) studied the effect of the implementation of a joint-commission certified TBI program at the San Francisco General Hospital (an urban level 1 trauma center). After implementation of the program in 2011, patient data was tracked from 2011-2013 and expected versus observed mortality was compared to a patient database from 1987-1996 which acted as a historical control. The 2011 TBI program reduced the percentage of early mortality by 59%, and 6-month mortality by 22%, compared with the historical control. However, the authors suggest that adopting evidence-based guidelines was not sufficient; they also tracked compliance to ensure that the guidelines were implemented properly. Fakhry et al. (2004) compared patient outcomes before and after implementation of a protocol in 1995 following the BTF guidelines. After implementation, initial analysis indicated compliance with the protocol was only about 50%; however, by 1997, compliance had improved to 88%. Thus, the authors evaluated length of stay and total charges of patients during 3 time points: 1991-1994 (pre-protocol), 1995-1996 (post-protocol, low compliance), and 1997-2000 (post-protocol, high compliance). The authors found that length of stay and total charges per patient dropped in each of the time periods measured, and mortality was decreased between the 1991-94 and 1997-2000 cohorts. These results indicate that both the implementation of guidelines and the ability to comply with them can make significant differences on patient outcomes.

TBI care in the acute setting is vital due to the risk of secondary brain injury resulting from increased intracranial pressure or insufficient cerebral perfusion pressure. Since healthcare practitioners have many physiological factors and treatment options to consider when devising a treatment plan, all while being under the pressure of time, an evidence-based, standardized treatment protocol may be particularly warranted in the acute setting. One study examined the efficacy of a formalized TBI early intervention program in comparison to hospitals that lack formalized TBI programming (Mackay et al., 1992). The authors found that the implementation of a formalized early intervention program resulted in significantly lower length of comas, length of stays, significantly higher mean cognitive levels at discharge, and a significantly higher percentage of discharges to home versus extended care facilities.

Conclusions

There is level 2 evidence that implementation of a protocol based on the American Association of Neurologic Surgeons TBI guidelines may improve mortality compared to patients with TBI prior to guideline implementation.

There is level 2 evidence that implementation of a standard treatment protocol based on generally accepted best practices may decrease mortality and improve discharge Glasgow Outcome Scale scores compared to patients with TBI prior to treatment protocol implementation.

There is level 2 evidence that implementation of a neurocritical care consult service, introduction of mutual neurocritical care/neurosurgery rounds, introduction of a TBI protocol, and clustering of patients with a neurocritical care diagnosis in the same unit may improve hospital mortality compared to prior protocols post TBI.

There is level 2 evidence that a joint commission-certified TBI program may reduce 24 hour and 6 month mortality compared to patients with TBI prior to program implementation.

There is level 2 evidence that implementation of a protocol based on the Brain Trauma Foundation guidelines may reduce mortality in patients with TBI compared to retrospective controls, but only if compliance with the protocol is sufficient.

There is level 3 evidence that a formalized early intervention program may reduce coma duration and length of stay, and improve cognitive levels at discharge and percent of discharges to home, compared to extended care facilities in patients with TBI.

Implementation of TBI protocols based on guidelines from the American Association of Neurologic Surgeons, the Brain Trauma Foundation, or generally accepted best practices may improve mortality and patient outcomes in patients with TBI; however this may only be the case if protocol compliance is sufficiently high.

Implementation of a neurocritical care consult service, introduction of mutual neurocritical care/neurosurgery rounds, introduction of a TBI protocol, and clustering of patients with a neurocritical care diagnosis in the same unit may improve hospital mortality post TBI.

Formalized early intervention programs can reduce coma duration and hospital length of stay, and improve cognitive levels at discharge and rate of discharges to home, in patients with TBI.

3.2.2 Institutional Comparisons

Facility type is also of prime interest relative to the specific needs of the patient. Trauma care facilities have proven to be superior to general care facilities for emergency medical care. MacKenzie et al. (2007) noted patients with head injuries, Abbreviated Injury Scale score ≥3, showed a 90% survival rate at 12-month follow up in trauma centers compared to 64.3% in non-trauma centers. The availability of trauma centers tends to be dictated by local needs and resources. In the absence of such a facility, local centers must be able to handle ABI individuals effectively and transport them when necessary to a properly equipped center. This section provides an overview of studies assessing institutional differences in ABI care.

Table 3.2 Institutional Comparisons for Acute Management Post ABI

Author/Year/ Country/Study Design/N	Methods	Outcome
Harris et al. (2008) USA Cohort N=1,607	**Population:** TBI; *Hospital 1 (n=691):* Mean Age=38.3 yr; Gender: Male=511, Female=180; Severity: Mild=414, Moderate=57, Severe=161. *Hospital 2 (n=782):* Mean Age=34.8 yr; Gender: Male=633, Female=149; Severity: Mild=324, Moderate=77, Severe=91. *Hospital 3 (n=134):* Mean Age=34.6 yr; Gender: Male=109, Female=25; Severity: Mild=82, Moderate=19, Severe=17. **Intervention:** Data from three hospitals that provide neurosurgical care was extracted from a	1. Patients cared for in hospital 1 had more severe head injuries, received more CT scans (p<0.0001), and were more likely to be admitted to the Intensive Care Unit than those attending hospitals 2 and 3 (p<0.0001). 2. Patients in hospital 1 were more likely to receive intracranial pressure monitoring. 3. There were no statistically different differences in mortality rates between the three sites, except severe patients cared

	National Trauma Registry. Hospital 1 was in the USA and Hospitals 2 and 3 in Jamaica. **Outcome Measure:** Medical intervention use, Mortality rates, Glasgow Outcome Scale (GOS), and Functional Independence Measure (FIM).	for in the USA had a decreased risk of mortality (OR 0.47, p=0.04). 4. Patients cared for in the USA had lower mean GOS scores (p<0.0001) and lower FIM scores for self-feed (p=0.0003), locomotion (p=0.04), and verbal (p<0.0001).
DuBose et al. (2008) USA Case Control N=16,035	**Population:** TBI; Mean Age=40.7 yr; Gender: Male=11,169, Female=4866. **Intervention:** Data on patients managed in level I and level II trauma centers was extracted from the National Trauma Data Bank and compared. **Outcome Measure:** Injury Severity Scale (ISS), Mortality, Medical complications, and clinical procedures.	1. After adjustments for patient differences, those managed in a level 2 trauma center had increased mortality, more complications and greater likelihood of progression of neurologic insult (all p<0.001). 2. ISS≥20, Age≥55, GCS≤8, admission to Level 2 trauma centers, penetrating mechanism and hypotension on admission were all significant risk factors for mortality (all p<0.001).

Discussion

Strategies for the management of ABI care vary widely depending on accessibility to resources and the patient population that the healthcare institution serves. Comparing outcomes between institutions with different management strategies may provide much needed information as to what practices are effective at specific levels of resource availability. Two studies were found that compare outcomes for patients with TBI across healthcare institutions that have markedly different management strategies.

Harris et al. (2008) followed TBI care in one US hospital and two Jamaican hospitals to evaluate TBI management strategies in developed versus developing countries. The hospital in the US had more advanced technology and provided more aggressive neurological support. Specifically, the US hospital performed CT scans more frequently, used intracranial pressure monitors more often, and admitted a higher proportion of patients to the ICU. Interestingly, despite the greater availability or resources and higher aggressiveness of treatment at the US site, the overall mortality rates did not differ between hospitals. Notably, however, in the subset of patients with severe head injury, mortality was significantly reduced at the US site. Patients with more severe injuries may benefit from more aggressive treatment strategies.

DuBose et al. (2008) aimed to compare severe TBI patient outcomes between trauma centers with different designations. The American College of Surgeons (ACS) designates trauma centers into 1 of 3 levels according to available resources, education, and research (Committee on Trauma of the American College of Surgeons, 1999). Previous studies of severe trauma patients have shown that level 1 trauma centers have better mortality and morbidity rates than their level 2 counterparts (Demetriades et al. 2005). In this study, a total of 16,037 severe TBI patients were split into two groups based on the center in which they were treated (level 1 or level 2). Patients treated at the level 1 trauma center had lower mortality rates, lower rates of complications, and less progression of neurologic insult.

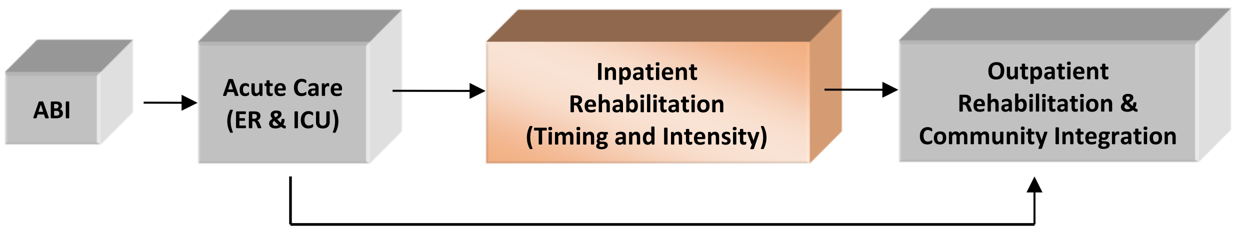
Conclusions

There is level 2 evidence that hospitals that perform computerized axial tomography scans more frequently, use intracranial pressure monitors more often, and admit a higher proportion of patients to the intensive care unit, may have lower severe TBI mortality rates.

There is level 3 evidence that level 1 trauma centers may have lower severe TBI mortality rates than level 2 trauma centers.

Greater resource availability and more aggressive care may improve mortality in patients with severe TBI.

3.3 Inpatient Rehabilitation



The rehabilitation of patients with ABI involves a comprehensive effort by an interdisciplinary team including physicians, nurses, physical therapists, speech-language pathologists, occupational therapists, and social workers. Considering the incidence, consequences, and costs of ABI, it is important to understand the relative efficacy of rehabilitation methods.

While many patients with ABI are discharged directly home or to a long-term care facility, others are discharged to a dedicated inpatient rehabilitation service. These services vary from institution to institution but generally include some type of intensive therapy program for physical, social, behavioural, and cognitive difficulties. Deciding who should receive inpatient rehabilitation remains a major challenge. Patient referral decisions are inherently complex and need to be understood as a dynamic phenomenon shaped by characteristics of the individual. However, they also rely on the interactions and interpretations of health professionals who operate within unique organizational and broader health care contexts (Foster & Tilse, 2003). These decisions are also influenced by social and funding issues. For example, in the US patients insured by Medicaid or a Healthcare Maintenance Organization were more likely to go to a skilled nursing facility, rather than inpatient rehabilitation, relative to people with commercial fee-for-service plans (Chan et al., 2001). In Canada, patients aged 36 to 45 years old with more co-morbid conditions are more likely to receive rehabilitation than those older than 65, rural dwellers, non-English speaking people and individuals with mental health, alcohol and/or drug problems (Colantonio et al., 2004). The diversity of patient needs has also led to the formation of differing systems of rehabilitation. In Calgary, for instance, the Halvar Johnson Centre has established a slow stream rehabilitation program for individuals with TBI who may require slightly extended care.

Due to the unique challenges posed by ABI, the structure of inpatient rehabilitation is extremely diverse. Patients are generally rehabilitated in one of two centers: a general rehabilitation unit or a coordinated multidisciplinary neurorehabilitation unit. Some argue that an effective rehabilitation service requires a multidisciplinary team, which includes nursing care, physician monitoring, psychologist and social work intervention, physiotherapists, occupational therapists, and speech language pathologists, among other things (Cifu et al., 2003). In reality, differences in care often amount simply to the availability of neuro-rehabilitative beds and facilities. Limited resources mandate decisions regarding which patients will benefit most from inpatient rehabilitation compared to community-based programs.

Debate also exists about appropriate targets of rehabilitative care. Traditional rehabilitation models in other disciplines such as stroke, spinal cord, and polio have focused on orthopedic and neuromotor impairments (Cope et al., 2005). Brain Injury rehabilitation initially followed a similar path; however, an increased focus was then placed on cognitive and behavioral remediation (Mazaux & Richer, 1998), as well as coma stimulation (Cope et al., 2005). Patients in need of skill application training are often discharged to community based services while inpatient rehabilitation has focused more on intensive, short term physical or cognitive rehabilitation (Evans, 1997). Furthermore, some inpatient facilities have recognized the need to divide patients into different streams during rehabilitation. At the Toronto Rehabilitation Institute, for example, patients have been streamed into a Neurocognitive group and a Neurophysical group since 2002 (Cullen, 2007).

Inpatient rehabilitation typically begins when a patient is medically stable enough to be transferred out of acute care and into a dedicated rehabilitation unit for a defined period of interdisciplinary rehabilitation. There is a great deal of variability in the length, type, and intensity of services provided in programs throughout the world. As such, we delineate the evidence supporting the various aspects of treatment for inpatient care delivery (Table 3.3).

Table 3.3 Models of Inpatient Rehabilitation for ABI

Author/Year/ Country/Study Design/N	Methods	Outcomes
Cullen et al. (2013) Canada Case Control $N_{initial}$=138, N_{final}=130	**Population:** TBI; *Streamed Group (n=65):* Mean Age=44.02 yr; Gender: Male=49, Female=16. *Control (n=65):* Mean Age=44.46 yr; Gender: Male=40, Female=25. **Intervention:** Retrospective review of patients who received treatment according to either a traditional neurorehabilitation model or a functionally-based streamed model. In the streamed model patients were divided into a neurocognitive (NC) stream for predominantly cognitive/behavioural deficits, or a neurophysical (NP) stream for predominantly physical deficits. **Outcome Measure:** Length of stay, Functional Independence Measure (FIM), and Disability Rating Scale.	1. The NP group had higher FIM motor subscale efficiency than controls (0.41 versus 0.29; p=0.01). 2. The NC group had less disability (Disability Rating Scale) compared to controls (3.63 versus 5.05, p=0.01). 3. Groups did not differ significantly on length of stay, FIM discharge scores, total FIM gain, or total FIM efficiency.
Semlyen et al. (1998) UK PCT N=51	**Population:** TBI; *Group 1 (n=33):* Mean Age=36 yr; Gender: Male=28, Female=5; Mean Time Post Injury=49.37 days; Mean GCS=5.03. *Group 2 (n=18):* Mean Age=30 yr; Gender: Male=15, Female=3; Mean Time Post Injury=17.94 days; Mean GCS=5.39. **Intervention:** Two groups were observed. Group 1 received a coordinated multidisciplinary rehabilitation program in a regional rehabilitation center and Group 2 received single-discipline	1. Within the first 6mo of treatment, Group 1 made rapid gains on the BI (p<0.001), NIAF (p<0.0001), FIM Motor (p<0.01) and FIM Cognitive (p<0.05). Group 2 made improvements only up to 12 wk post injury on the NIAF (p<0.05) and FIM Cognitive (p<0.05), but not on BI or FIM motor.

Author/Year/ Country/Study Design/N	Methods	Outcomes
	rehabilitation provided in local hospitals. Assessments were completed at 4 wk, 8 wk, 12 wk, 6 mo, 12 mo and 24 mo post-treatment. Caregivers were assessed at 12 wk, 6 mo and 12 mo after patient's admission. **Outcome Measure:** Functional Independence Measure (FIM), Barthel Index (BI), Newcastle Independence Assessment Form (NIAF), and General Health Questionnaire.	2. Group 1 demonstrated functional gains over the 12 to 24 mo period, making significant gains on the BI and the NIAF (both p<0.05). 3. Caregivers of those in the Group 2 reported significantly higher levels of distress for somatic symptoms (p=0.001). Social dysfunction, whilst non-significant, was also much higher for the Group 2 caregivers (p=0.057).

Discussion

In a case control study, Cullen et al. (2013) assessed the efficacy of a functionally-based neurorehabilitation program that places patients into treatments groups based on their predominant functional deficits. Patients with predominantly physical or cognitive deficits were streamed into a neurophysical or neurocognitive rehabilitation group, respectively. When compared with historical controls who received traditional ABI inpatient care, the neurophysical stream had significantly higher functional independence measure efficiency, and the neurocognitive stream had significantly lower disability rating scale scores. It may be more beneficial to rehabilitate patients based on their specific functional or cognitive deficits rather than focusing on general all-inclusive ABI care strategies, or "rehabilitation by diagnosis".

Another issue is that brain injury often leads to multiple deficits that span across many disciplines. Thus, patients would likely benefit from receiving comprehensive care from multiple areas of expertise. Semlyen et al. (1998) compared two distinct TBI inpatient rehabilitation strategies. One group of patients received a coordinated, multidisciplinary regional rehabilitation service, and another received a local, single discipline approach. The multidisciplinary rehabilitation group made significant gains up to 6 months according to the functional independence measure, and up to 24 months according to the Barthel Index and Newcastle independence assessment form, whereas the single discipline approach group made significant gains only up to 12 weeks post injury. Notably, the site where the multidisciplinary approach group was treated likely had greater access to resources than other sites, which may have confounded results.

Conclusions

There is level 3 evidence that functionally-based streamed models of inpatient ABI care, particularly neurophysical and neurocognitive streams, may improve functional independence measure efficiency and reduce disability rating scale scores, respectively, compared to traditional inpatient rehabilitation.

There is level 2 evidence that a coordinated, multidisciplinary inpatient rehabilitation approach may improve TBI motor and cognitive patient outcomes longer-term (up to, 24 months) compared to single discipline treatment.

Functionally-based streamed models of inpatient rehabilitation may improve targeted deficits more than all-encompassing traditional inpatient rehabilitation methods in patients with TBI.

Compared to a single-discipline approach, a coordinated, multidisciplinary approach to inpatient rehabilitation may result in functional improvements that are sustained for longer in patients with TBI.

3.3.1 Intensity of Inpatient Rehabilitation

While patients are undergoing rehabilitation the intensity of therapy provided to them is potentially an important factor in promoting neurological and functional recovery. We review the evidence for increased intensity in this section.

Table 3.4 Intensity of Inpatient Rehabilitation Post ABI

Author/Year/ Country/Study Design/N	Methods	Outcome
Zhu et al. (2001) Hong Kong RCT PEDro=8 N=36	**Population:** TBI; *Conventional (n=21):* Mean Age=33 yr; Gender: Male=17, Female=4; Severity; Severe=13, Moderate=8. *Intensive (n=15):* Mean Age=30 yr; Gender: Male=11, Female=4; Severity: Severe=10, Moderate=5. **Intervention:** Patients were randomized into two groups: the intensive group received 4 hr/day of therapy 5 days/wk while the conventional treatment group received 2 hr/day. Assessments were completed monthly for the first 6 mo, then bi-monthly up to 1 yr. **Outcome Measure:** Glasgow Outcome Scale (GOS) and Functional Independence Measure (FIM).	1. A greater proportion of patients from the intensive group achieved "good" GOS outcome 2 mo into treatment, compared with the conventional group (40% versus 10%; p=0.046). This difference, however, diminished from 3 mo onwards. 2. While there were no significant differences in mean FIM motor, cognitive and total scores, there appeared to be a trend in favour of the Intensive group.
Shiel et al. (2001) UK RCT PEDro=7 N=56	**Population:** ABI; *Group 1 (n=12):* Mean Age=34.2 yr. *Group 2 (n=13)*: Mean Age=36.2 yr. *Group 3 (n=12)*: Mean Age=37 yr. *Group 4 (n=14)*: Mean Age=39 yr. **Intervention:** Patients were randomly assigned to an intervention group with increased therapy intensity or a control group at two separate hospitals. Groups 1 and 2 were recruited from Southampton General Hospital and Groups 3 and 4 were recruited from Poole Hospital. Groups 1 and 3 received intensive therapy and Groups 2 and 4 received routine therapy. **Outcome Measure:** Functional Independence Measure and Functional Assessment Measure, Length of Stay	1. Patients in Groups 3 and 4 were discharged significantly earlier (p=0.004) and received more routine therapy per week (p=0.0099) than patients in Groups 1 and 2. 2. Length of stay was not significantly different between the overall intervention group (groups 1 and 3) and the control (groups 2 and 4). 3. Patients in Groups 1 and 3 made significantly faster gains in self-care, psychosocial function (both p<0.001), continence (p=0.001), transfers (p=0.002), locomotion, cognition (both p=0.008) and communication (p=0.01) compared to patients in groups 2 and 4.
Webb & Glueckauf, (1994) USA RCT PEDro=5 N=16	**Population:** TBI; Mean Age=27.4 yr; Gender: Male=14, Female=2. **Intervention:** Patients were assigned to either a high (n=8) or low (n=8) involvement neurorehabilitation goal-setting group. Assessments were completed 1wk pre-	1. Both groups made significant improvements in obtaining their goals from pre- to post-intervention (p<0.01) but there were no significant differences between groups. 1. Patients who had high involvement in their neurorehabilitation goal-setting

Author/Year/ Country/Study Design/N	Methods	Outcome
	intervention, 1 wk post-intervention and at 2 mo follow-up. **Outcome Measure:** Goal Attainment Scaling, Galveston Orientation and Amnesia Test.	maintained their improvements at 2mo follow-up (p<0.001) whereas patients who received low involvement demonstrated a decline in the number of goals attained.
Hart et al. (2016) Denmark PCT N=274	**Population:** TBI; *US Group (n=145)*: Mean Age=37.5 yr; Gender: Male=101, Female=44. *Denmark Group (n=129):* Mean Age=39.6 yr; Gender: Male=103, Female=26. **Intervention:** Patient outcomes from 2 TBI treatment centers were compared; a US center and a Denmark center where patients received significantly greater intensity and duration of rehabilitation. **Outcome Measure:** Functional Independence Measure (FIM), Glasgow Outcome Scale (GOS), Disability Rating Scale, Participation Assessment with Recombined Tools, Perceived Quality of Life, Medical Outcome Study 12-Item Short-Form Health Survey, Brief Symptom inventory.	1. Injury severity on admission was greater at the Denmark site compared to the US site. The DK center also provided significantly more rehabilitation services for both functional and emotional components (p<0.001). 2. After adjusting for injury severity upon admission, there were no significant differences in functional or emotional outcomes between the Denmark and US site at 12 months post-TBI.
Cicerone et al. (2004) USA PCT N=56	**Population:** TBI; *Group 1 (n=27):* Mean Age=37.8 yr; Gender: Male=17, Female=10; Mean Time Post Injury=33.9 mo. *Group 2 (n=29):* Mean Age=37.1 yr; Gender: Male=23, Female=6; Mean Time Post Injury=4.8 mo. **Intervention:** Patients participated in one of two groups: Group 1 took part in an intensive cognitive rehabilitation program and group 2 was given a standard neurorehabilitation program for 4 mo. **Outcome Measure:** Community Integration Questionnaire (CIQ), Trail-Making Test Parts A and B, California Verbal Learning Test, Controlled Oral Word Association Test, Rey Complex Figure, and Category Test.	1. Both groups showed significant improvements on total CIQ scores following treatment (p<0.001). There was also a between -group difference, with participants in Group 1 showing greater improvement than those in Group 2 (p=0.021). 2. Patients in Group 1 demonstrated significant improvements in neuropsychological function from pre- to post-treatment (p<0.001). Neuropsychological function was not evaluated for Group 2. 3. There was a significant difference in patients' satisfaction with community functioning; patients in Group 2 indicated greater levels of satisfaction than patients in Group 1 (p=0.03).
Cifu et al. (2003) USA PCT N=491	**Population:** TBI; Mean Age=34.3 yr; Gender: Male=354, Female=137; Mean GCS=7.98. **Intervention:** Inpatient rehabilitation data from three medical centers was collected from the Traumatic Brain Injury Model Systems database. Patients received a combination of rehabilitation therapies, including speech, psychological, occupational and physical therapy. **Outcome Measure:** Functional Independence Measure, Length of Stay (LOS), and hours of therapy.	1. Rehabilitation intensity predicted motor functioning at discharge (p<0.001), but did not predict cognitive gain. 2. Cognition and motor abilities at admission significantly predicted LOS (p<0.01).
Spivack et al. (1992) USA Case Series	**Population:** TBI; Mean Age=38.6 yr; Gender: Male=61, Female=34; Mean Time Post Injury=62.4 days; Mean GCS=8.8.	1. For physical performance, higher-level cognitive skills and cognitively mediated physical skills, all subjects showed improvements from admission to

Author/Year/ Country/Study Design/N	Methods	Outcome
N=95	**Intervention:** Data was obtained from monthly medical records at a comprehensive inpatient rehabilitation program. Time spent and intensity of rehabilitation therapies were also observed including physical therapy, cognitive remediation, neuropsychology and therapeutic recreation. **Outcome Measure:** Physical Performance*, Higher-level Cognitive Skills*, Cognitively Mediated Physical Skills*, Rancho Los Amigos Levels of Cognitive Functioning Scale (RLAS) *Denotes seven-point functional status scales developed by the clinicians within each rehabilitation discipline.	discharge. The short LOS group was significantly better than the long LOS group at admission (p<0.05); however, at discharge all outcome measures were comparable between the 2 groups. 2. The effect of training intensity in the first month on physical performance and cognitively mediated physical skills was not significant and approached significance for higher level cognitive skills (p=0.06). 3. A significant interaction between training intensity for the first month and RLAS was obtained, with those in the high intensity group showing greater improvements (p<0.05).
Blackerby, (1990) USA Case Control N=86	**Population:** TBI=83, Other=3. **Intervention:** Retrospective analysis of 2 hospitals that increased their rehabilitation intensity from 5 hr/day to 8 hr/day, 7 days/wk. Patients who underwent rehabilitation before the intensity increase were compared to those who underwent rehabilitation after. **Outcome Measure:** Length of Stay (LOS).	1. Increased rehabilitation therapy resulted in a 31% decrease in LOS for both coma and acute groups at both hospitals in the study (p<0.05). 2. Patients in the coma group experienced an average LOS reduction of 48.43 days and the acute group averaged 52.87 days in reduced LOS.

Discussion

A number of studies were found that have evaluated the efficacy of increased intensity of inpatient rehabilitation on patient outcomes and length of stay following brain injury. In a multicenter PCT, Cifu et al. (2003) examined the efficacy of rehabilitation intensity on functional outcomes at discharge. Rehabilitation intensity predicted motor functioning at discharge but not cognitive gain. Cicerone et al. (2004) found that intensive and structured cognitive rehabilitation therapy (group and individual) and standard neurorehabilitation therapy both resulted in improvements on the community integration questionnaire; however, in the more intensive program, participants made greater gains in cognitive functioning. In another study, Spivack et al. (1992) found that intensity of treatment in the first month of inpatient rehabilitation did not have a significant effect on any of the outcomes measured. However, the authors used functional status scales that were developed by the clinicians within each rehabilitation discipline, and the validity of these scales remains unknown. In an RCT by Zhu et al. (2001), patients were randomized into two groups based on rehabilitation intensity. One group received 4 hours per day of therapy and another received 2 hours per day, with both groups receiving therapy 5 days per week. The authors reported significantly more patients from the intensive group achieving good outcomes at 2 months as defined by Glasgow Outcome Scale; however, this effect was not sustained at 3 months as the conventional therapy group caught up. Moreover, there were no differences between groups in functional independence measures. This study suggests that more intensive rehabilitation may provide added benefits in the first two to three months post injury, but as time progresses, those who receive less intensive therapy eventually catch up.

Length of stay is another important factor to consider that is closely related to rehabilitation intensity. Blackerby et al. (1990) assessed the effect of different levels of rehabilitation intensity on length of stay. In two separate hospitals, rehabilitation intensity was increased from 5 hours per day to 8 hours per day, 7 days per week. When comparing those who received less intensive therapy with those who received the more intensive regimen, the latter group was discharged an average of 1.5 months earlier. Moreover, the variability in length of stays was decreased in the intensive rehabilitation group, making length of stay easier to predict.

Another factor to consider is the type of rehabilitation that patients are undergoing. Some rehabilitation efforts will benefit more from increased intensity than others. For example, Webb and Glueckauf (1994) found that patients who had greater involvement in goal-setting maintained their improvements at study follow-up; in contrast, those with low involvement in their goal setting showed a decline in the number of goals attained. Not surprisingly, it is beneficial to have a more intense patient involvement in this case, as it ensures the goals are meaningful, and thus the motivation of the patient is increased.

It could also be true that the effectiveness of increased rehabilitation intensity likely depends on the site where the patient is receiving care. If the rehabilitation institution has limited access to resources, this may reduce the efficacy of higher intensity rehabilitation. In a 2-center RCT by Sheil et al. (2001) patients in the intervention group received additional therapy from a health care professional (a rehabilitation nurse at one center and an occupational therapist at the other) who provided these extra services as necessary. The authors found that patients receiving additional therapy made improvements at discharge on both the functional independence measure and the functional assessment measure; however, these improvements were facility specific. While the larger facility showed greater functional improvements and reduced length of stay in the intensive therapy group compared to the standard therapy group, this was not the case at the smaller facility. The intensive group at the smaller facility showed no significant improvements in functional scores or length of stay. These results may be related to the amount of staffing and resources available to the patients; the larger center could have incorporated intensive therapy more easily due to resource availability.. In another study, two rehabilitation sites, one in Denmark and the other in the USA, were compared (Hart et al., 2016). While the Denmark site provided significantly more rehabilitation services for functional and emotional components, no significant differences in functional or emotional outcomes were found at 12 months post TBI. However, this study tracked both inpatient and outpatient rehabilitation services for 1 year post TBI, thus the effect of inpatient rehabilitation intensity alone could not be determined. It is also worth noting that although controlled for in the analysis, the Denmark group had significantly higher injury severity upon admission.

Relatively few studies have evaluated the impact of intensity on rehabilitation, and of the studies that have, results are varied and unclear. Intuitively, it seems reasonable to assume that more intensive therapy will result in more rapid and ultimately greater improvement in recovery from brain injury. Based on the available literature, greater intensity appears to result in a faster recovery in the short term and therefore shorter lengths of stay, but not necessarily better long-term outcomes, as those with a lower intensity rehabilitation regimen tend to catch up.

Conclusions

There is level 1b evidence that more intensive inpatient rehabilitation may improve Glasgow Outcome Scale scores at 2 months, but not necessarily at 3 months and beyond, compared to conventional treatment in patients with TBI.

There is level 3 evidence that increasing inpatient rehabilitation intensity may reduce hospital length of stay compared to conventional therapy post ABI.

There is level 2 evidence that inpatient therapy intensity post ABI predicts motor functioning at discharge.

Increasing inpatient rehabilitation intensity can reduce hospital length of stay post ABI.

Increasing inpatient rehabilitation intensity, compared to standard therapy, can improve Glasgow Outcome Scale scores and functional outcomes post ABI in the short term.

The efficacy of increasing inpatient rehabilitation intensity post ABI can change based on the rehabilitation institution and available resources.

Inpatient therapy intensity predicts motor functioning post ABI at discharge.

3.3.2 Timing of Inpatient Rehabilitation

It has long been identified that early onset of therapeutic interventions for those who have sustained a TBI is beneficial. Understanding the ideal time to initiate rehabilitation will help maximize the usefulness of resources that are available to patients for a limited amount of time. At one end of the spectrum, a comatose patient may be unable to engage in therapy, while at the other end of the spectrum someone who has made a good recovery has no need for intervention. Several studies have shown that introducing a rehabilitation program during the acute phase assists in the overall recovery of individuals with a TBI (Heinemann AW, 1990). A review by Cope (1995) concluded that those who receive early intervention do in fact have better outcomes than those who do not. Further, León-Carrión et al. (2013) reported that patients who received neurorehabilitation earlier demonstrated better global functioning at discharge than patients who began treatment at a later point. We attempt to address the question of the ideal time to start the rigors of therapy, as well as review the available evidence regarding the effectiveness of delayed ABI rehabilitation in order to maximize patient function and quality of life.

Table 3.5 Timing of Inpatient Rehabilitation Post ABI

Author/Year/ Country/Study Design/N	Methods	Outcomes
Formisano et al. (2016) Italy Case Control N=651	**Population:** TBI; Mean Age=43.67 yr; Gender: Male=516, Female=135; Severity: Severe. **Treatment:** Participants were recruited from an inpatient rehabilitation centre and categorized by time from injury to rehabilitation (latency). **Outcome Measures:** Length of stay (LOS), Disability Rating Scale (DRS).	1. There was a significant positive correlation between latency and LOS (p<0.01). 2. There was a significant positive correlation between latency and mean admission DRS (p<0.01). 3. There was a significant positive

Author/Year/ Country/Study Design/N	Methods	Outcomes
		correlation between latency and mean discharge DRS ($p<0.01$). 4. There was a positive correlation between latency and the number of participants retransferred to acute care ($p>0.05$).
Bender et al. (2014) Germany Case Series N=125	**Population:** TBI=38, Intracerebral Hemorrhage=23, Stroke=23, Anoxic Encephalopathy=20, Unknown=1; Mean Age=50.4 yr; Gender: Male=73 Female=53. **Intervention:** Retrospective analysis of a group of severe ABI patients who participated in an early rehabilitation program (ERP), followed by an inpatient interval rehabilitation program (IRP) a mean of 1.5 years later. **Outcome Measure:** Goal Attainment Scale, Barthel Index (BI), Functional Independence Measure (FIM), and Coma Remission Scale.	1. Thirty-seven percent of IRP inpatients were successful overall in achieving their goals; success rates varied based on primary goals: 86.7% for decannulation, 34.6% for improvements in Activities of Daily Living (ADL), 30% for improvement in dysphagia, 17% for other individual goals ($p<0.001$). 2. Improvement in FIM scores was found during ERP, community care and also IRP ($p<0.001$). 3. BI scores improved significantly during ERP ($p<0.001$) and continued to improve during IRP ($p<0.001$).
High et al. (2006) USA PCT $N_{Initial}$=167, N_{Final}=141	**Population:** TBI; *Group 1 (n=115):* Mean Age=31.5 yr; Gender: Male=86, Female=29. *Group 2 (n=23)*: Mean Age=32.8 yr; Gender: Male=14, Female=9. *Group 3 (n=29)*: Mean Age=27.2 yr; Gender: Male=18, Female=11. **Treatment:** Patients were enrolled in a comprehensive, integrated post-acute brain injury rehabilitation program. Patients were grouped depending on length of time between injury and admission: <6 mo (Group 1), 6-12 mo (Group 2), and >12 mo (Group 3). Patients participated in an interview at admission, discharge and at approximately 1.5 yr follow-up. **Outcome Measure:** Disability Rating Scale (DRS), Supervision Rating Scale (SRS), and Community Integration Questionnaire (CIQ).	1. For those in Group 1, DRS scores from admission to discharge improved significantly ($p<0.001$). Such improvements were not seen in Groups 2 or 3. 2. SRS scores decreased from admission to follow-up for Group 1 at all time-points (all $p<0.001$). 3. Groups 2 and 3 reported significant decrease in supervision between admission and discharge ($p=0.001$ and $p=0.002$ respectively) but no significant change was observed between discharge and follow-up. 4. All groups demonstrated improvements in CIQ between admission and discharge ($p<0.001$) and between discharge and follow-up ($p=0.003$). 5. Social integration improved significantly between admission and follow-up ($p=0.014$) for all groups.
Wagner et al. (2003) USA Case Control N=1,866	**Population:** TBI; *Group 1 (n=520):* Mean Age=48.5 yr; Gender: Male=339, Female=181; Severity: Severe=178, Mild/Moderate=326. *Group 2 (n=1,346):* Mean Age=39.4 yr; Gender: Male=939, Female=407; Severity: Severe=90, Mild/Moderate=1163. **Treatment:** A comparison was conducted between Group 1, patients who received physical medicine and rehabilitation consultation and those who did	1. Patients in Group 1, compared to Group 2, were more likely to have worse mFIM scores at acute discharge ($p=0.05$), have at least one premorbid condition ($p=0.002$) and have significantly longer length of stay (11.85 days versus 2.47 days, $p<0.001$). 2. For group 1, when the consultations occurred earlier (<48hr after hospital admission) patients experienced

Author/Year/ Country/Study Design/N	Methods	Outcomes
	not (Group 2). Data was extracted from hospital records. **Outcome Measure:** Modified Functional Independence Measure (mFIM).	significantly better mFIM scores for transfers and locomotion (both p=0.05) and had significantly shorter acute length of stay (p=0.001).
Edwards et al. (2003) USA Cohort N=290	**Population:** ABI: TBI=110, Intracerebral Hemorrhage/Subarachnoid Hemorrhage/Cerebral Infarction=122, Other=58; Mean Age=38 yr; Gender: Male=193, Female=97. **Treatment:** Data was extracted from a hospital database. Patient assessments were conducted within 4 wk of admission, every 6-8 wk and at discharge. Patients were retrospectively split into two group, those admitted <200 days post-injury (n=264) and those admitted >200 days post-injury (n=26). **Outcome Measure:** Length of Stay, Barthel Index (BI), and Functional Independence Measure (FIM).	1. Rehabilitation length of stay was similar for the two groups. 2. Lower BI and FIM scores at admission were significant predictors for increased length of stay for all patients (both p<0.001). 3. Discharge BI and FIM scores were lower in the admitted >200 days post-injury group than the <200 days post-injury group (BI, 11 versus 14; FIM, 77 versus 92 respectively), but the differences were not significant.
Tuel et al. (1992) USA Case Series N=49	**Population:** ABI; Mean Age=23.6 yr; Gender: Male=38, Female=11; Mean Time Post Injury=2.9 yr. **Intervention:** Data was obtained from records of patients readmitted to inpatient rehabilitation more than 12 mo after injury. **Outcome Measure:** Barthel Index (BI).	1. Fifty-three percent (n=26) showed improvement (mean BI gain of 11.2 points). 2. Statistically significant improvements of BI scores were shown from re-admission to discharge (p=0.0001). 3. Length of readmission was significantly correlated with improvements in BI (p=0.0016).
Cope and Hall, (1982) USA Case Control N=36	**Population:** ABI; *Early Group (n=16):* Mean Age=29 yr; Gender: Male=9, Female=7; Mean Time Post Injury=20.88 days; Mean GCS=5.54. *Late Group (n=20):* Mean Age=29.15 yr; Gender: Male=15, Female=5; Mean Time Post Injury=61.35 days; Mean GCS=5.11. **Treatment:** Patients were retrospectively assigned to one of two groups: an Early Rehabilitation Group which consisted of patients admitted to a rehabilitation facility at ≤35d post-injury or a Late Rehabilitation Group with patients admitted to a rehabilitation facility at >35d post-injury. **Outcome Measure:** Disability Rating Scale, Glasgow Outcome Scale, Social Status Outcome (SSO).	1. Both groups reached equivalent levels of functional recovery at discharge and SSO ratings at 2 yr post-injury. 2. Those in the Late Group spent significantly more time in acute care (p=0.001) and inpatient rehabilitation (p=0.01) than the Early Group. 3. At 2 mo post-injury, patients in the Early Group experienced significantly less psychological impairment (p=0.02), and fewer problems with bowel and bladder function (p=0.05) than the Late Group.

Discussion

In this section, our analysis is two-fold. First, we review studies that evaluate the effect of earlier acute intervention on functional outcomes and length of stay, then we assess the relative efficacy of rehabilitation in the chronic phase of ABI.

In a case control study by Formisano et al. (2016), patients from an inpatient rehabilitation center were categorized by time from injury to initiation of rehabilitation. Patients who began rehabilitation sooner after injury had lower length of stays, lower initial disability rating scale scores, and higher mean discharge disability rating scale scores. Wagner et al. (2003) examined the proper timing for physical medicine and rehabilitation consultation. Using multivariate analysis, the authors found that when Physical Medicine and Rehabilitation consultations occurred earlier (<48 hours after hospital admission) patients experienced significantly better functional independence measure scores for transfers and locomotion and had significantly shorter lengths of stay. Cope and Hall (1982) reported that those in a late intervention (>35 days) group spent significantly more time in acute care and inpatient rehabilitation. Edwards et al. (2003) compared 26 patients admitted to inpatient rehabilitation more than 200 days after injury to 264 patients admitted to inpatient rehabilitation less than 200 days after injury. Although it was not significant, the discharge scores on the Barthel Index and functional independence measure were lower in the former group than in the latter. Rehabilitation LOS was also similar for the two groups. Generally, it seems that patients who sustain an ABI benefit from earlier initiation of rehabilitation.

However, a number of studies have also shown that although it is beneficial to begin rehabilitation soon after sustaining an ABI, rehabilitation efforts in the chronic phase can still result in significant improvements. Bender et al. (2014) reported an improvement in functional independence measure scores during early rehabilitation, community care, and inpatient interval rehabilitation. Although patients entered the inpatient interval rehabilitation program an average of 1.5 years after discharge from the early rehabilitation program, they still demonstrated improvement-rate increases comparable to initial rehabilitation levels, where the greatest gains are said to be made, highlighting the benefit of additional rehabilitation at later stages of recovery. This point has been made by earlier studies as well. A study noted that 53% of patients readmitted to inpatient rehabilitation at more than 12 months post injury showed statistically significant improvement on Barthel Index scores from readmission to discharge (Tuel et al., 1992). In a PCT, modest findings were reported from High et al. (2006). All three time groups (time since injury of less than 6 months, 6 to 12 months, greater than 12 months) demonstrated a significant decrease in required supervision from admission to discharge; however, the less than six month group continued to improve through to follow-up.

Conclusions

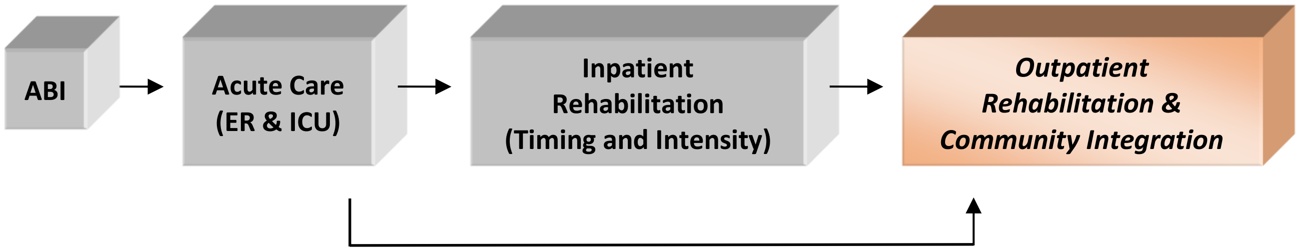
There is level 2 evidence that inpatient rehabilitation within 35 days post ABI is associated with better outcomes such as shorter comas and hospital length of stay, higher cognitive levels at discharge, better Functional Independence Measure scores, and a greater likelihood of discharge to home, compared to rehabilitation initiated after 35 days post-ABI.

There is level 2 evidence that individuals with an ABI can still benefit from inpatient rehabilitation efforts initiated more than 12 months after sustaining an ABI compared to those who received earlier treatment.

Early inpatient rehabilitation is associated with better outcomes in individuals post ABI.

Inpatient rehabilitation in the chronic phase of ABI can still yield meaningful results.

3.4 Outpatient Rehabilitation and Community Reintegration



Outpatient care is often the least organized branch of ABI care. Patients discharged home often receive no therapy or minimal support depending on their level of need and payment status. In a well-structured outpatient facility in Canada, patients typically attend therapy two to three times per week and have access to an occupational therapist, physiotherapist, speech language pathologist, social worker, physiatrist, neuropsychologist, and neuropsychiatrist (Cullen, 2007). At some facilities, for example in Hamilton, Ontario, patients also receive the services of a rehabilitation counselor. Access to programs like these often depends on funding. Patients with private insurance from motor vehicle accidents are 1.6 times more likely to be discharged home with supportive services than those without (Kim et al., 2006). Drag et al. (2013) reported that US TBI-veterans were significantly more likely to utilize outpatient services and were almost nine times more likely to be hospitalized than non-TBI veterans. The authors argue that earlier intervention and increased monitoring may be needed to reduce the burden on outpatient healthcare (Drag et al., 2013). In a study by Leith et al. (2004), focus groups of patients and families were questioned regarding their perceived post-discharge needs. The five areas of need included: early, continuous, comprehensive service delivery; information and education; formal and informal advocacy; empowerment of persons with TBI and their families; and human connectedness and social belonging (Leith et al., 2004). Subsequently, a survey was conducted in the US to identify the availability of community information resources post-ABI (Sample & Langlois, 2005). Three recommendations for improvement were made: expand the population targeted for linkage to services, improve access to information about available services, and increase the availability of services (Sample & Langlois, 2005).

Residential care facilities are generally not-for-profit, government sponsored agencies that offer access to support in a secure environment with staff specifically trained in ABI care. Resources often include rehabilitation therapists, behaviour therapists, social workers, and case managers, with supervision by certified psychologists (Powell et al., 2002). These facilities aim to allow patients with ABI an extended system of support, with opportunities for long-term rehabilitation. However, they are generally expensive and access is often limited by the patient's ability to pay for care. Alternatives include hospital based outpatient facilities where patients drop in several times a week for care (Cullen, 2007) or mobile rehabilitation teams which visit the patient in their home (Ponsford et al., 2006). Programs targeting specific goals including social interaction (Cope et al., 2005), driving (Rapport et al., 2008) and competitive employment (Willer et al., 1999) also exist. They generally take place on a one-to-one basis in home or in the community and patients often rate these final steps as the most important in returning to normalcy (Evans, 1997).

While most patients move back to their former living environment with therapy intervention provided for them in the home or community, some go on to other facilities that may provide longer duration treatment for those that are slow-to-recover. There are numerous models of care within community-based rehabilitation. In regards to social re-entry, Martelli (2012) argues that peer support interventions are effective in reintegrating individuals and should be incorporated into community rehabilitation models. Avocational and vocational reintegration are also important factors as the former can improve functionality, strength, and endurance, while the latter improves productivity, self-worth, and life satisfaction. Vocational reintegration can be facilitated through the case coordination model whereby the patient collaborates with a case coordinator who assesses the services needed and makes appropriate referrals on the patient's behalf (Martelli et al., 2012); studies discussing a wider range of vocational rehabilitation interventions can be found in Module 13 (Community Reintegration). Lack of services could be an issue, thus a supported employment program or a program-based model could also be utilized.

Ashley et al. (2012) proposed a new community-based interventional model that focuses on cognitive attributes. The proposed model incorporates tasks that assist with attention, perceptual processing, and categorization. The authors point out that previous research has found re-establishing neuronal connections that become damaged after a TBI leads to greater cognitive functioning in patients. For the model to be successful, Ashley et al. (2012) state that the tasks need to be errorless, with high levels of repetition and redundancy in order for the intervention to be successful. As this model of care can be extremely time-consuming, it is suggested that this be utilized in a community-based rehabilitation center.

Table 3.6 Outpatient Rehabilitation and Community Reintegration Post ABI

Author/Year Country/Study Design/N	Methods	Outcome
Peirone et al. (2014) Italy RCT PEDro=8 N=16	**Population:** ABI; *Intervention Group (n=8):* Mean Age=39.62 yr; Gender: Male=4, Female=4; Mean Time Post Injury-14 mo. *Control Group (n=8):* Mean Age=40.5 yr; Gender: Male=5, Female=3; Mean Time Post Injury=14.5 mo. **Intervention:** All patients received 50 min of physiotherapy 3x/wk for 7 wk. The intervention group also received additional dual-task exercises 6x/wk including balance and body stability whilst performing a motor task (throw/catch a ball) or a cognitive test. **Outcome Measure:** Balance Evaluation System Test (BEST), Activities-specific Balance Confidence Scale (ABC), and Goal Attainment Scaling (GAS).	1. Both the Intervention group and the control group improved significantly on the BEST (p=0.014 and p=0.02 respectively) but when comparing the two, the Intervention group displayed significantly greater improvements (p=0.008). 2. On the ABC, the intervention group made significant improvements from baseline (p=0.01). There was no significant difference between the groups at the end of the study. 3. Both intervention and control groups experienced significant improvements on the GAS (p=0.02 and p=0.01 respectively) but no significant difference was found between the two groups.
Hassett et al. (2009) Australia RCT PEDro=8 N=62	**Population:** TBI; *Fitness Group (n=32):* Mean Age=35.4 yr; Gender: Male=27, Female=5; Severity: Very Severe=9, Extremely Severe=23. *Home Group (n=30):* Mean Age=33 yr; Gender: Male=26, Female=4; Severity: Very Severe=11, Extremely Severe=19. **Intervention:** Patients were randomly assigned to receive either a supervised fitness center-based therapy program or an unsupervised home-based program. Assessments were completed at	1. Patients in both groups improved in cardio-respiratory fitness but there were no significant differences between groups. 2. At the end of the intervention, the fitness group reported significantly greater total scores on SPRS (p=0.033) but the difference was not significant at follow-up.

Author/Year Country/Study Design/N	Methods	Outcome
	baseline, at completion of the intervention and at 3 mo follow-up. **Outcome Measure:** Goals, 20 m Shuttle Test, Body Mass Index, Waist-to-Hip-ratio, and Sydney Psychosocial Reintegration Scale (SPRS).	3. The fitness group also reported significantly more goals achieved at the end of the intervention (p=0.005) but this also became non-significant at follow-up.
Powell et al. (2002) UK RCT PEDro=8 N=94	**Population:** TBI; *Outreach Group (n=48):* Mean Age=34 yr; Gender: Male=37, Female=11; Mean Time Post Injury=4yr. *Information Group (n=46):* Mean Age=35y r; Gender: Male=34, Female=12; Mean Time Post Injury=2.7 yr. **Intervention:** Patients were randomly allocated to one of two groups. The Outreach group received multi-disciplinary therapy for 2 hr/wk for a mean of 27.3 wk in a community setting and the information (control) group received a specially collated booklet with resources. Patients were assessed at 18 mo and 40 mo. **Outcome Measure:** Barthel Index (BI), Functional Independence Measure + Functional Assessment Measure (FIM+FAM), and Brain Injury Community Rehabilitation Outcome-39 (BICRO-39).	1. Of the 92 subjects who completed the study, 35% of the Outreach group improved their scores on the BI compared to 20% of the Information group (p<0.05). 2. Improvements for FIM+FAM scores approached statistical significance when measuring level of personal care (p<0.06) and cognition (p<0.09) for the Outreach group compared to the information group. All other FIM+FAM subscales were non-significant. 3. The Outreach group demonstrated significantly greater improvement on the BICRO-39 than the Information group (p<0.05).
Eicher et al. (2012) USA Cohort N=604	**Population:** ABI; *Group 1 (n=235):* Mean Age=41.65 yr; Gender: Male=136, Female=99. *Group 2 (n=78):* Mean Age=38.95 yr; Gender: Male=62, Female=16. *Group 3 (n=246):* Mean Age=35.42 yr; Gender: Male=185, Female=61. *Long-term Group 4 (n=45):* Mean Age=35.78 yr; Gender: Male=33, Female=12. **Intervention:** Four rehabilitation programs were assessed: Group 1 received Intensive Outpatient & Community-based Rehabilitation, Group 2 received Intensive Residential Rehabilitation, Group 3 received Long-term Residential Supported Living, and Group 4 received Long-term Community-based Supported Living. Mean follow-up time was 5-6 mo for Groups 1, 2 and 4, and 8 mo for Group 3. **Outcome Measure:** Mayo-Portland Adaptability Inventory (MPAI-4).	1. Programs with an intense rehabilitation program (Groups 1 and 2) demonstrated significant improvements on the MPAI-4 compared to Groups 3 and 4 (p=0.002). 2. At baseline assessment, patients in Groups 1 and 2 scored significantly lower than patients in Groups 3 and 4 in adjustment (p<0.001) and ability (p<0.05). 3. At the second assessment, patients in Groups 1 and 2 scored significantly better on ability (p<0.006) and participation (p<0.001) than patients in Groups 3 and 4. 4. There was no statistical difference on adjustment at second assessment.
Braunling-McMorrow et al. (2010) PCT N=205	**Population:** TBI; *Neurorehabilitation Group (NR; n=129)*: Mean Age=36.6 yr; Gender: Male=89, Female=40; Mean Time Post Injury=15 mo. *Neurobehavioural Group (NB; n=76)*: Mean Age=32 yr; Gender: Male=63, Female=13; Mean Time Post Injury=56 mo. **Intervention:** Individuals were divided into 2 groups: those receiving NR services and those requiring specialized NB services due to behavioural or psychiatric issues. Both groups participated in behavioural and cognitive therapy programs. Assessments were completed at pre-admission, admission, discharge, and 3mo, 6mo and 12 mo post-discharge.	1. Individuals in both groups showed significant functional gains from admission to discharge (p<0.001). 2. Functional gains were also made from admission to 1 yr follow up (p<0.001). 3. The NR group made greater overall gains than those in the NB group (p<0.001). 4. Gains made by both groups were noted at the 1 yr follow up; whereas NB group continued to make significant gains from discharge to follow-up (2.93 to 3.23; p<0.05), the NR group maintained their gains (3.68 to 3.60; p>0.05).

Author/Year Country/Study Design/N	Methods	Outcome
	Outcome Measure: Functional Area Outcome Menu.	5. Results also found that NR patients admitted within 6 mo of injury made the greatest improvement (p<0.001). There was no significant effect of time post injury for the NB group.
[Ponsford et al.](#) (2006) Australia Cohort N=154	**Population:** TBI; *Community Group (n=77):* Mean Age=35.43 yr; Gender: Male=56, Female=21; Mean GCS=8.22. *Outpatient Group (n=77):* Mean Age=33.78 yr; Gender: Male=56, Female=21; Mean GCS=7.76. **Intervention:** Patients treated in a community based rehabilitation program were matched with patients who attended the hospital for outpatient rehabilitation. Assessments were completed every 3 mo during treatment then at 1 and 2 yr follow-ups. **Outcome Measure:** Craig Handicap Assessment and Reporting Technique, and Structured Outcome Questionnaire.	1. Patients treated in the community were significantly more dependent on support from close others (p=0.008), less independent in mobility (p=0.005), had greater difficulty with motor speech (p=0.005) and following conversations (p=0.001), and displayed more inappropriate social behaviours (p=0.009) than the outpatient group. 2. Patients treated in the community demonstrated increased physical independence (p=0.004) compared to patients in the outpatient group.
[Willer et al.](#) (1999) USA/Canada Case Control N=46	**Population:** TBI; *Treatment Group (n=23):* Mean Age=33.42 yr; Gender: Male= 20, Female=3; Mean Time Post Injury=3.05 yr. *Control Group (n=23):* Mean Age=34.76 yr; Gender: Male=20, Female=3; Mean Time Post-Injury=4.66 yr. **Intervention:** Patients admitted to a community-based residential rehabilitation treatment center were compared to a matched control group receiving rehabilitation at home or in a nursing facility. Assessments were completed at admission, discharge and at 1 yr follow-up by staff or relatives. **Outcome Measure:** Health Activity Limitation Survey and Community Integration Questionnaire (CIQ).	1. Patients in the treatment facility showed significant improvement in motor and cognitive functioning at 1 yr follow-up compared to the controls (p<0.05). 2. The two groups did not differ significantly on the CIQ at discharge or at follow-up, but the treatment group demonstrated significantly greater improvement from admission to discharge than the control group (p<0.001).

PEDro = Physiotherapy Evidence Database rating scale score (Moseley et al., 2002)

Discussion

In terms of outpatient and community care, there are several similarities to inpatient rehabilitation. A multidisciplinary approach is still favourable for outpatient services, and timely rehabilitation is imperative as patients are often sent home too early and referred to outpatient services too late (Jeyaraj et al., 2013). Braunling-McMorrow et al. (2010) looked at the benefits of participation in a weekly program that included both behavioural and cognitive therapies that would teach participants to respond to various life events appropriately and allow for greater independence. Those in the neurobehavioural group admitted within the first six months of injury showed greater improvement than those admitted later. The study authors suggest that injury severity may have been a factor, with more severe cases being admitted sooner. As well, for those admitted later, gains had already been made and this may have made the gains in the program appear less significant (Braunling-McMorrow et al., 2010).

Similar to inpatient rehabilitation, intensity of care is an important factor to consider when patients are discharged back into the community and receive care on an outpatient basis. A longer duration of rehabilitation is generally suggested, but with lower intensity to allow patients more time to integrate back into daily life. However, one study has provided evidence that outpatient rehabilitation programs with greater intensity appear to be more effective. Eicher et al. (2012) compared four different outpatient and community rehabilitation programs: an intensive outpatient and community-based program, an intensive residential rehabilitation program, long-term residential supported living, and long-term community-based supported living. The more intensive programs provided more functional benefits, whereas supported living programs resulted in relatively stable scores on the Mayo-Portland Adaptability Inventory. Jeyaraj et al. (2013) note that there is a need to train clinicians who provide community services about how best to assist individuals with ABI and increase the amount of community resources available to them. More studies are required to determine an optimal balance between providing intense outpatient rehabilitation programs versus allowing patients time to reintegrate into society and tackle the responsibilites of daily life in the community.

A number of studies have assessed the effectiveness of different types of outpatient rehabilitation programs. Ponsford et al. (2006) compared outpatients treated in the community to those who returned to the hospital for outpatient care. The findings indicate that patients who received outpatient care were significantly less dependent on support from close others, more independent in mobility, displayed fewer inappropriate social behaviours, and had less difficulty with motor speech and following conversations than those receiving community-based rehabilitation. No significant differences were shown in terms of employment outcomes. One of the main targets for community-based rehabilitation is to assist the patient in their transition into independent living. Independence is a key component of self-efficacy and allows us to live an autonomous life. Powell et al. (2002) randomly assigned patients with TBI to an outpatient support program where patients received two to six hours of therapy a week at home or in another community setting, or to a control group that received an information session at home. Patients in the intervention group showed improvements in cognitive functioning, mobility, and personal wellbeing. Areas such as socializing and competitive employment rates showed no relative difference between groups; the authors suggest that this reflects external influences beyond the control of the rehabilitation team. The authors recommend that this type of outpatient approach be applied to a broader range of patients with ABI in a larger trial to confirm their results. In terms of where outpatient services are provided, one study found that patients with TBI given rehabilitation in a residential treatment center made significantly greater gains in terms of motor and cognitive functioning than those receiving rehabilitation in a nursing facility or at home (Willer et al., 1999). The groups, however, did not differ at discharge or at a one year follow-up on a measure of community integration (Willer et al., 1999).

Two RCTs specifically looked at the relative effectiveness of different outpatient exercise/physiotherapy programs. Hassett et al. (2009) randomized patients to a supervised fitness center-based exercise program or an unsupervised home-based program and found that both groups at follow-up made comparable gains in terms of psychosocial and physical functioning. Although the fitness group achieved more goals post intervention, the difference was not significant at follow-up. This study highlights that these programs are equally as effective which is positive for individuals who cannot access or prefer not to attend community center fitness programs. In an RCT conducted by Peirone et al. (2014), while all patients received physiotherapy to target balance impairments, those in the intervention group also received a dual-task home-based program. The program was provided six days a week over seven weeks and resulted in this group making significantly greater gains in terms of balance then the control group. While improvements were also shown on the goal attainment scale and a balance confidence scale, the between-group differences were not significant. Unfortunately, the results are hard to interpret due to being underpowered and the inability to distinguish whether the improvements are based on the program itself or simply the increase in rehabilitation intensity as a result of adding an additional therapy.

Conclusions

There is level 2 evidence that earlier initiation of outpatient and community based rehabilitation is associated with better functional outcomes compared to residential rehabilitation in individuals with an ABI.

There is level 2 evidence that more intensive outpatient rehabilitation programs are associated with better functional outcomes compared to standard therapy in individuals with an ABI.

There is level 2 evidence that compared to individuals with an ABI who are treated in the community, those treated at an outpatient clinic may be less dependent on support from others, more independent in mobility, display fewer inappropriate social behaviours, and have less difficulty with motor speech.

There is level 1b evidence that a supervised fitness-center based program may be equally as effective as an unsupervised home-based program for improving cardiorespiratory fitness in individuals with an ABI.

There is level 2 evidence that a high-level of involvement in neurorehabilitation goal setting may result in a greater number of attained goals being maintained at follow-up (two months) compared to neurobehavioral therapy in individuals with an ABI.

There is level 3 evidence that outpatient care provided at a residential treatment center may improve motor and cognitive function to a greater extent than when care is provided at a nursing facility or at home in individuals with a TBI.

Earlier outpatient rehabilitation is associated with better outcomes post ABI.

More intensive outpatient rehabilitation is associated with better functional outcomes post ABI. However, this may not be the case if intensity is high enough to interfere with a patient's ability to perform day to day responsibilities.

Compared to individuals with an ABI who are treated in the community, those treated at an outpatient clinic may be less dependent on support from others, more independent in mobility, display fewer inappropriate social behaviours, and have less difficulty with motor speech.

High-level involvement in neurorehabilitation goal setting may result in a greater number of attained goals being maintained at follow-up (two months) in individuals with an ABI.

Outpatient care provided at a residential treatment center may improve motor and cognitive function to a greater extent than when care is provided at a nursing facility or at home in individuals with a TBI.

3.4.1 Vocational Rehabilitation

Returning to work following ABI is one of the most challenging tasks that a patient will face in the course of their recovery. The work environment often produces stresses on their physical body, cognitive challenges, and emotional strain. However, given the financial burden of not being able to work for most individuals, it is a very important aspect of full reintegration into society and return to independent living.

Table 3.7 Intensity of Outpatient Rehabilitation for Vocational Rehabilitation Post ABI

Author/Year Country/Study Design/ N	Methods	Outcome
Ownsworth et al. (2008) Australia RCT PEDro=8 N=35	**Population:** TBI=21, Stroke=12, Tumor=2; Mean Age=43.89 yr; Gender: Male=19, Female=16; Mean Time Post Injury=5.29 yr. **Intervention:** Patients were randomly allocated to one of six intervention groups: group-based support, individual occupation-based support or a combination of the two (each of these three interventions had its own waitlist which served as a control group). Relatives and patients completed questionnaires at baseline, post intervention and at 3 mo follow-up. **Outcome Measure:** Canadian Occupational Performance Measure (COPM), Brain Injury Community Rehabilitation Outcome-39 (BICRO-39), and Patient Competency Rating Scale (PCRS).	1. COPM self-performance ratings improved significantly within groups from pre-intervention to follow-up in the individual-based (p<0.025), group-based and combined (both p<0.01) intervention groups. 2. There were no significant between group differences for COPM measures (all p>0.05). 3. Psychological improvements measured by the BICRO-39 were demonstrated from pre- to post-intervention by the patients in the group-based support intervention (p<0.01) and between pre-treatment and follow-up (p<0.025). The individual-based support intervention also demonstrated improvement between pre-treatment and follow-up (p<0.025). 4. Relatives of the patients in the individual-based intervention reported significant improvements on the PCRS at both post-intervention (p<0.025) and at follow-up (p=0.034). Significant improvement was also reported by relatives of group-based patients at follow-up (p<0.025).
Malec & Degiorgio (2002) USA Secondary Analysis of PCT N=114	**Population:** TBI=73, Other=41; Mean Age=37.4 yr; Gender: Male=70, Female=44; Mean Time Post Injury=65.5 mo; Severity: Severe=64, Moderate=8, Mild=24, Undetermined=18. **Intervention:** Patients in three rehabilitation pathways were observed: specialized vocational services (SVS) only (n=49), SVS and a 3 hr/wk community reintegration outpatient group (CROG; n=21), and SVS and a 6 hr/day comprehensive day treatment (CDT; n=44). Assessments were completed by patients and staff at 1 yr follow-up.	1. No significant differences in CBE rates between all three groups: SVS=77%, CROG=85%, CDT=84% (p>0.1). 2. There were no significant differences between patient MPAI scores across all three groups, except for driving (p<0.001) with 71% of the SVS group and 60% of the CROG group receiving no driving concerns from others compared to only 26% for the CDT group. 3. There were significant differences in staff MPAI scores with the SVS group

Author/Year Country/Study Design/ N	Methods	Outcome
	Outcome Measure: Mayo-Portland Adaptability Inventory (MPAI), Vocational Independence Scale, and community-based employment status (CBE).	experiencing fewer memory (p<0.01) and problem-solving (p<0.001) impairments, and greater attention and concentration abilities (both p<0.001) compared to the other groups. 4. Patients in the CROG group were more likely to live independently than those in the SVS or CDT groups (p<0.001).

Discussion

Two studies have focused on the ability of outpatient or community rehabilitation to help ABI patients return to work. Ownsworth et al. (2008) performed an RCT to compare individual occupation-based support, group-based support, and a combination of the interventions for goal attainment and psychosocial functioning. The individual occupation-based support contributed to gains in performance in goal-specific areas. The combined intervention was associated with maintained gains in satisfaction and performance, while the group and individual interventions were more likely to result in gains in behavioural competency and psychological well-being. In another study, Malec and Degiorgio (2002) reported that patients in three different rehabilitation pathways, who differed in terms of cognitive functioning and disability, were able to succeed in terms of community-based employment. The study highlights the need for an individualized approach to ensure successful integration into the community. The intensity of therapy and the resources and interventions offered must match the individual's needs, severity of injury, and goals, among other factors (Malec & Degiorgio, 2002).

Conclusions

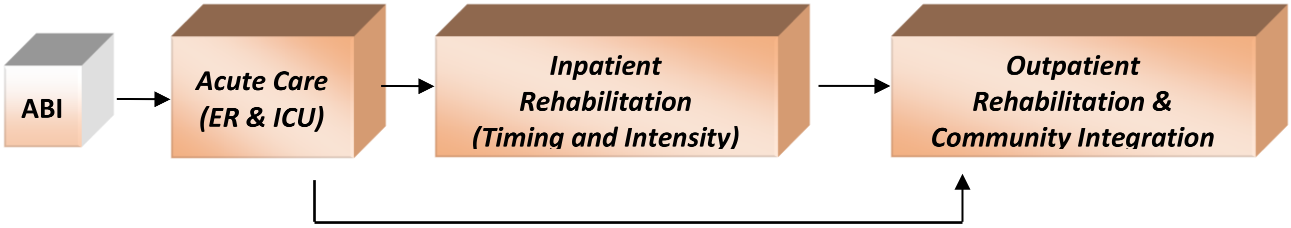
There is level 1b evidence that neither individualized nor general vocational rehabilitation programs may improve performance in goal-specific areas compared to waitlist controls in individuals with ABI.

There is level 2 evidence that combining specialized vocational rehabilitation services with a community reintegration outpatient group intervention or comprehensive day treatment may not improve community based employment compared to specialized vocational rehabilitation alone in individuals with ABI.

Individualized and group vocational rehabilitation programs can improve goal-specific performance and behavioural competency/psychological well-being in individuals post ABI, respectively.

Combining specialized vocational rehabilitation services with a community reintegration outpatient group intervention or comprehensive day treatment may not improve community based employment compared to specialized vocational rehabilitation alone in individuals with an ABI.

3.5 Complete Care Pathways



The goal in any rehabilitation stream is to provide seamless care from the onset of injury to the ultimate recovery. As this module has demonstrated, the continuum of ABI care involves acute interventions with a transition to some combination of rehabilitation therapies. This section aims to identify studies which have compared pathways of care combining several rehabilitation strategies.

Table 3.8 Comprehensive Care Pathways for Individuals with an ABI

Author/ Year/ Coutnry/ Study Design/ N	Methods	Outcomes
Glintborg et al. (2016) Denmark PCT N=82	**Population:** ABI; *KORE group (n=27)*: Mean Age=53.6 yr; Gender: Male=16, Female=11; Diagnosis: Apoplexia=21, TBI=6. *ALT group (n=18)*: Mean Age=52 yr; Gender: Male=14, Female=4; Diagnosis: Apoplexia=16, TBI=2. *SR group (n=37)*: Mean Age=53.4 yr; Gender: Male=17, Female=20; Diagnosis: Apoplexia=25, Stroke=12. **Intervention:** Participants who received the coordinated rehabilitation program (KORE) were compared with participants receiving standard treatment (SR group) and alternative treatment (ALT group). **Outcome Measure:** Functional Independence Measure (FIM), Major Depression Inventory (MDI), WHO-Quality of Life-BREF (WHOQOL-BREF), Impact on Autonomy and Independence Questionnaire (IPAQQ-DK).	1. FIM improved significantly in all groups from hospitalization after ABI to discharge (KORE: p<0.001, r=0.56; ALT: p<0.001, r=0.62; SR: p<0.001, r=0.58). At 1 yr post discharge, only the ALT group had a significant increase in total FIM score (p<0.001, r=0.48). There were significant differences between groups in total FIM score at discharge (p<0.001). Post hoc analysis showed the ALT groups FIM score was significantly lower than the KORE group (p<0.01, r=0.36). 2. Signs of clinical depression at discharge were observed in 30% of clients in the KORE group and 22% of those in the ALT group. MDI scores increased non-significantly from discharge to 1-2 yr post discharge. Depression rates did not differ significantly between groups at any time point. 3. No significant change in any of the QOL scores from discharge to 1-2 yr post discharge was recorded. In the KORE and ALT groups, 74% and 77% of clients respectively, reported being dissatisfied with their physical QOL. 4. Indoor autonomy significantly improved from discharge to 1-2 yr post discharge in both the KORE group (p<0.001, r=0.43) and the ALT group (p<0.001, r=0.49). The ALT group also reported significantly negative changes in family roles (p<0.05, r=0.38) and a reduction in outdoor problems (p<0.001, r=0.50).
Andelic et al. (2014) Norway Case Control N=59	**Population:** TBI; *Continuous Group (n=30):* Gender: Male=23, Female=7. *Broken-Chain Group (n=29):* Gender: Male=22, Female=7. **Intervention:** Two rehabilitation trajectories were explored: continuous and broken-chain.	1. Patients in the continuous chain group experienced an additional 4.06 points gain in DRS compared to the Broken-chain group (19.40 versus 23.46).

Author/ Year/ Coutnry/ Study Design/ N	Methods	Outcomes
	Clinical data on patients who had been admitted to rehabilitation between 2005 and 2007, and had received 6 wk, 1 yr and 5 yr follow-ups post-injury was analyzed. **Outcome Measure:** Disability Rating Scale (DRS) and costs of treatment.	2. The cost for the continuous group from acute care through to rehabilitation was 37,000 NOK (approx. $6,075.5 USD) less than the broken chain group.
Harradine et al. (2004) Australia Cohort N=198	**Population:** TBI; *Urban (n=147):* Mean Age=32.1 yr; Gender: Male=117, Female=30. *Rural (n=51):* Mean Age=32.1 yr; Gender: Male=38, Female=13. **Intervention:** Questionnaires were administered to patients at rehabilitation admission then again at 18 mo follow-up. Patients were compared based on where they lived (urban or rural). **Outcome Measure:** Disability Rating Scale (DRS), Mayo–Portland Adaptability Inventory (MPAI), General Health Questionnaire 28-item version (GHQ-28), and Medical Outcomes Short Form Health Survey (SF-36).	1. There were no significant differences between the two groups for scores on the DRS, MPAI, GHQ-28, and SF-36 questionnaires at 18mo follow-up. 2. There were no significant differences between the two groups in return to work rate or functional outcomes at follow-up. 3. In both groups, fewer patients were living alone compared to pre-injury; more were living with parents post-injury but this did not reach statistical significance.
McLaughlin & Peters (1993) USA Cohort N=31	**Population:** ABI; *Step-Up Group (n=19):* Mean Age=26.6 yr; Gender: Male=18, Female=13; Mean Time Post injury=16.68 mo. *Inpatient Group (n=12):* Mean Age-26.6 yr, Gender: Male=18, Female=13; Mean Time Post Injury=18.3 mo. **Intervention:** Patients in the Step-Up Group participated in a transitional living setting inpatient rehabilitation program and were compared with patients receiving inpatient rehabilitation alone. Data collected over 18 mo through a post discharge survey. **Outcome Measure:** Rancho Los Amigos Levels of Cognitive Functioning Scale (RLAS), Barthel Index (BI), and surveys on independent living and performance post-discharge.	1. Patients in the Step-Up Group reported greater functional independence on the BI than patients who received inpatient rehabilitation alone. 2. Although patients in the Step-Up group reported better independent skills, they did not differ with the inpatient group on employment rates, participation in volunteer work or in RLAS scores.

Discussion

These studies re-affirm many of the concerns already noted in this module. There is significant heterogeneity in caring for individuals with ABI and direct comparison of complete systems is difficult. No matter what health care system is assessed, budgetary concerns play a role in the accessibility of care. As a result, difficult decisions need to be made regarding resource allocation. Despite financial concerns, Khan et al. (2002) provide encouraging news regarding decreases in LOS and fiscal savings brought on by an integrated ABI system in Canada. The authors state that care needs to be taken to ensure that savings do not arise from sacrifices in quality of care but rather from the improvement of systematic inefficiencies. Moreover, Andelic et al. (2014) report that a continuous chain of treatment and interventions worked out to be more cost-effective than the 'broken chain' format of rehabilitation with patients receiving inconsistent interventions. Thus, patients transitioning smoothly through the continuum of care not only benefit in terms of functional and cognitive gains, but approximately $6,075.5 USD per patient was saved (Andelic et al., 2014). Finally, Harradine et al. (2004) note that coordination of regional facilities resulted in an equal availability of resources despite geographic challenges in New South Wales, Australia.

Continuity and accessibility of services is crucial to allow a patient the greatest opportunities for rehabilitation. Regional differences in resource availability need to be taken into consideration, along with patient demographics, so that the correct pathway decisions can be made. An alternative model of care is a comprehensive rehabilitation case management approach; this was implemented within a brain injury rehabilitation service and evaluated by Kennedy et al. (2012). A series of interviews with case managers and brain injury staff revealed that the new model provided a consistent and continuous transition through the rehabilitation continuum.

Conclusions

There is level 2 evidence that individuals post ABI living in both rural and urban settings may have greater functional gains from an integrated network of inpatient, outpatient, and community services compared to standard inpatient rehabilitation.

Although continuity of care has been shown to be beneficial in optimizing recovery, there is insufficient evidence to draw conclusions regarding the ideal structure of a complete model of ABI care. Further research is required in determining the ideal structure of a complete model of ABI care.

3.6 Conclusions

As stated previously, this module is not concerned with the individual effect of an intervention, but rather the comparative effect of different models of rehabilitation. Overall, the majority of the literature provides support for the effectiveness of earlier (versus late), and higher intensity (versus standard) inpatient or outpatient rehabilitation. In terms of guideline implementation, although guidelines themselves can foster improvement, there need to be specific strategic plans in place for their uptake in order to improve patient outcomes. On an institutional level, there can be a variety of differences between institutions in terms of the provision of care, which can be due to differences in resources, staffing, staff training, and education.

The ultimate goal of any rehabilitation program is to fully reintegrate an individual back into society, both socially and vocationally. With this in mind, vocational rehabilitation programs which take a more holistic approach have generally been found to be more effective. Further information on community reintegration can be found in Module 13.

Lastly, the issue of heterogeneous complete care pathways raises the concern that individuals with similar needs and functional status can undergo drastically different trajectories of rehabilitation care. Although no consensus currently exists for the optimal trajectory of care, institutions should prioritize needs assessments of their patients to determine the best course of treatment. Further research is needed in this area to help develop standardized trajectories between clinical settings.

3.7 Summary

There is level 2 evidence that implementation of a protocol based on the American Association of Neurologic Surgeons TBI guidelines may improve mortality compared to patients with TBI prior to guideline implementation.

There is level 2 evidence that implementation of a standard treatment protocol based on generally accepted best practices may decrease mortality and improve discharge Glasgow Outcome Scale scores compared to patients with TBI prior to treatment protocol implementation.

There is level 2 evidence that implementation of a neurocritical care consult service, introduction of mutual neurocritical care/neurosurgery rounds, introduction of a TBI protocol, and clustering of patients with a neurocritical care diagnosis in the same unit may improve hospital mortality compared to prior protocols post TBI.

There is level 2 evidence that a joint commission-certified TBI program may reduce 24 hour and 6 month mortality compared to patients with TBI prior to program implementation.

There is level 2 evidence that implementation of a protocol based on the Brain Trauma Foundation guidelines may reduce mortality in patients with TBI compared to retrospective controls, but only if compliance with the protocol is sufficient.

There is level 3 evidence that a formalized early intervention program may reduce coma duration and length of stay, and improve cognitive levels at discharge and percent of discharges to home, compared to extended care facilities in patients with TBI.

There is level 2 evidence that hospitals that perform computerized axial tomography scans more frequently, use intracranial pressure monitors more often, and admit a higher proportion of patients to the intensive care unit, may have lower severe TBI mortality rates.

There is level 3 evidence that level 1 trauma centers may have lower severe TBI mortality rates than level 2 trauma centers.

There is level 3 evidence that functionally-based streamed models of inpatient ABI care, particularly neurophysical and neurocognitive streams, may improve functional independence measure efficiency and reduce disability rating scale scores, respectively, compared to traditional inpatient rehabilitation.

There is level 2 evidence that a coordinated, multidisciplinary inpatient rehabilitation approach may improve TBI motor and cognitive patient outcomes longer-term (up to, 24 months) compared to single discipline treatment.

There is level 1b evidence that more intensive inpatient rehabilitation may improve Glasgow Outcome Scale scores at 2 months, but not necessarily at 3 months and beyond, compared to conventional treatment in patients with TBI.

There is level 3 evidence that increasing inpatient rehabilitation intensity may reduce hospital length of stay compared to conventional therapy post ABI.

There is level 2 evidence that inpatient therapy intensity post ABI predicts motor functioning at discharge.

There is level 2 evidence that inpatient rehabilitation within 35 days post ABI is associated with better outcomes such as shorter comas and hospital length of stay, higher cognitive levels at discharge, better Functional Independence Measure scores, and a greater likelihood of discharge to home, compared to rehabilitation initiated after 35 days post-ABI.

There is level 2 evidence that individuals with an ABI can still benefit from inpatient rehabilitation efforts initiated more than 12 months after sustaining an ABI compared to those who received earlier treatment.

There is level 2 evidence that earlier initiation of outpatient and community based rehabilitation is associated with better functional outcomes compared to residential rehabilitation in individuals with an ABI.

There is level 2 evidence that more intensive outpatient rehabilitation programs are associated with better functional outcomes compared to standard therapy in individuals with an ABI.

There is level 2 evidence that compared to individuals with an ABI who are treated in the community, those treated at an outpatient clinic may be less dependent on support from others, more independent in mobility, display fewer inappropriate social behaviours, and have less difficulty with motor speech.

There is level 1b evidence that a supervised fitness-center based program may be equally as effective as an unsupervised home-based program for improving cardiorespiratory fitness in individuals with an ABI.

There is level 2 evidence that a high-level of involvement in neurorehabilitation goal setting may result in a greater number of attained goals being maintained at follow-up (two months) compared to neurobehavioral therapy in individuals with an ABI.

There is level 3 evidence that outpatient care provided at a residential treatment center may improve motor and cognitive function to a greater extent than when care is provided at a nursing facility or at home in individuals with a TBI.

There is level 1b evidence that neither individualized nor general vocational rehabilitation programs may improve performance in goal-specific areas compared to waitlist controls in individuals with ABI.

There is level 2 evidence that combining specialized vocational rehabilitation services with a community reintegration outpatient group intervention or comprehensive day treatment may not improve community based employment compared to specialized vocational rehabilitation alone in individuals with ABI.

There is level 2 evidence that individuals post ABI living in both rural and urban settings may have greater functional gains from an integrated network of inpatient, outpatient, and community services compared to standard inpatient rehabilitation.

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