ERABI EVIDENCE-BASED REVIEW of moderate to severe ACQUIRED BRAIN INJURY

2. Epidemiology and Long-term Outcomes Following Acquired Brain Injury

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Abbreviations

ABI	Acquired Brain injury
ALC	Alternative level of care
GCS	Glasgow Coma Scale
MVA	Motor Vehicle Accidents
nTBI	Non-Traumatic Brain Injuries
TBI	Traumatic Brain Injury

2.1 Epidemiology of Acquired Brain Injury

2.1 Introduction

Acquired brain injury (ABI), particularly traumatic brain injury (TBI), is one of the leading causes of death and lifelong disability in North America (Greenwald et al., 2003; Pickett et al., 2001; Thurman & Guerrero, 1999). In the United States between 1.4 and 1.7 million people sustain a TBI every year (Faul et al., 2010; Zaloshnja et al., 2008), with more than 120,000 people expected to develop long-term disabilities (Zaloshnja et al., 2008). In the province of Ontario, more than 80,000 individuals sustained a TBI between 2002 and 2006 (Colantonio et al., 2010). Among low and middle income countries, the lifetime prevalence of TBI ranges from 0.3% in China to 14.6% in rural Mexico (Khan et al., 2015); however, the global incidence of TBI is increasing due primarily to the increased use of motor vehicles in low and middle income countries (Maas et al., 2008). Recently, in high income countries, the epidemiological patterns of TBI have been shifting (Roozenbeek et al., 2013). An increase in the absolute incidence of TBI among older age individuals and an increase in the median age of TBI has been observed; the primary cause of TBI in the elderly is falls (Maas et al., 2008; Roozenbeek et al., 2013). Accordingly, in high income countries, improvements in safety regulations have been associated with a reduction in traffic related TBI (Redelmeier et al., 2003); however, motor vehicle accidents (MVA) remain one of the most common causes of TBI (Andriessen et al., 2011). Furthermore, in European countries, individuals were identified as being under the influence of alcohol at the time of their TBI in 24-51% of cases (Tagliaferri et al., 2006).

Most individuals with TBI are classified as having a mild injury, but residual deficits in these patients are not uncommon (Thornhill et al., 2000). However, 10-15% of patients with TBI have more serious injuries requiring specialist care (Maas et al., 2008). The frequency of moderate severity injury is increasing; moderate TBI accounted for 19% of injuries in 1992 compared with 37% of injuries in 2002 (Colantonio et al., 2009).

Much of the data pertaining to ABI is collected when patients present at a specific point of care (i.e., emergency departments, inpatient rehabilitation, and outpatient services). It should be noted that these studies do not explore the number of patients treated in other healthcare settings. Furthermore, the individuals who do not seek medical care, commonly those with mild TBI, are not accounted for (Roozenbeek et al., 2013). In addition, individuals with very severe TBI who die before reaching a hospital are often not registered (Roozenbeek et al., 2013). For these reasons, the number of individuals with a brain injury is likely to be higher than these figures suggest (Langlois et al., 2006).

This module will discuss demographic characteristics within the ABI patient population as well as how these characteristics relate to injury etiology. In addition, factors that influence rate of recovery and prognosis during the acute and chronic post injury time periods will be reviewed. The following information is not meant to be prescriptive in any way, as each ABI case should be considered individually when attempting to predict outcome and when determining the best course of treatment. The information in this module is designed to help clinicians better understand the complex relationships between patient characteristics, injury characteristics and outcomes post ABI. Many of the relationships discussed in this module are correlational in nature and should be interpreted with caution. Study inclusion criteria for this module is consistent with the inclusion criteria for interventional studies listed in Module One.

2.1 Sex Differences in ABI

The rate and etiology of injury seem to differ according to patient sex, with TBI being more common in males than females (CIHI, 2008; Colantonio et al., 2009; Colantonio et al., 2010; Greenwald et al., 2003). A study conducted in the United States found TBI to be nearly 1.4 times more common among males than females (Faul et al., 2010). Data from Ontario, Canada is consistent with this finding and also shows greater rates of TBI among males (Chan et al., 2013a). The increased incidence in males may in part be due to greater participation in risk-taking activities, exposure to occupational hazards, and more engagement in violent behaviours than females. A cohort study found that fall-related TBIs were more common among females than males (51.7% versus 36.2%, respectively); conversely, being struck by or against an object was more common among males than females (Colantonio et al., 2010). Females have also been shown to have 33.1% lower odds of mortality after adjusting for covariates than males post brain injury (Haring et al., 2015). However, these results are in contrast to one study in Spain, which found no association between sex and outcome after severe TBI (Herrera-Melero et al., 2015).

2.1.3 Age and ABI

Overall, motor vehicle or other transportation related accidents (MVAs) and falls are the most common causes of TBI (Faul et al., 2010). Falls and MVAs, together, were shown to account for approximately 75% of TBIs requiring hospitalization in Ontario from 1992 to 2002 (Colantonio et al., 2009). Based on literature, falls account for approximately 35% to 42% of TBIs whereas MVAs are responsible for 12% to 17% (Colantonio et al., 2010; Faul et al., 2010). These trends have been consistent for approximately ten years (Roozenbeek et al., 2013).

Evidence suggests that the etiology of TBI varies with age. Among children aged 0-4 years, up to two thirds of severe brain injuries are attributable to non-accidental trauma (Greenwald et al., 2003). Whereas among young adults, MVAs account for more than 60% of TBIs in those aged 16-25 years and 47% of TBIs in those aged 26-35 years (Colantonio et al., 2009). Falls are a common cause of TBI in both children and older adults (Colantonio et al., 2009; Faul et al., 2010); an epidemiological study conducted in the United States showed that falls accounted for 50.2% of TBIs in children (aged 0-14 years) and 60.7% of TBIs in adults aged 65 years or older (Faul et al., 2010). For those 85 years of age or older, the rate of hospitalization in Ontario for TBI due to a fall was as high as 90% (Chan et al., 2013b, 2013c). The increased risk of falls in the elderly may be linked to factors such as substance use, decreased balance and/or age-related neurological conditions such as dementia (Wagner, 2001).

With increasing age, the prevalence of brain injury due to non-traumatic causes also increases; non-traumatic brain injury (nTBI), which excludes patients with a primary diagnosis of stroke, is more prevalent in those over the age of 40 years. In Ontario, hospitalization rates for nTBI increase with age; rates of 365 persons per 100,000 have been reported for those 65-74 years old, compared to 561 persons per 100,000 for those above 85 years old (Chan et al., 2013b, 2013c). Vascular insults (not captured in other national studies on stroke), brain tumours, meningitis, encephalitis, and anoxia have been found to be the most frequent causes of nTBI (Chan et al., 2013b).

Recently, an increase in the rate of TBI among the elderly has been noted which is heavily influenced by the fact that they are the fastest growing sector of the population (Chan et al., 2013a; Roozenbeek et al., 2013). A recent examination of the Ontario ABI Dataset found that between 2003 and 2010, there was a significant increase in TBI cases among patients aged 65 to 74 years (11%), 75 to 84 years (50%) and 85 years and older (63%; (Chan et al., 2013a).

2.1.3.1 Impact of Older Age on TBI and Subsequent Recovery

Those who sustain a TBI, regardless of age, may develop circulatory, digestive, or respiratory problems; have an increased risk of infection; and may experience neurological complications such as endocrine abnormalities, seizures, and swallowing difficulties (Flanagan, 2008). Individuals with a TBI may also develop mental health concerns such as depression or anxiety (Colantonio et al., 2011).

Evidence suggests that age influences the trajectory of one's recovery following injury. Individuals in the older age bracket generally had poorer outcomes when compared to younger individuals (Marquez de la Plata et al., 2008). Pennings et al. (1993) found individuals over the age of 60 required a greater number of resources to obtain favourable outcomes compared to younger patients (≤40 years old) with a similar severity of injury. For those in the older age group, a longer length of stay in hospital was often necessary to address their slower rate of functional recovery (Chan et al., 2013a; Cifu et al., 1996). Both admission and discharge Functional Independence Measure scores from inpatient rehabilitation were lower among older adults (Chan et al., 2013b). Consequently, older adults also had a lower rate of discharge to the community (Colantonio et al., 2009).

Older age at the time of injury has also been associated with poorer performance in various cognitive domains (Senathi-Raja et al., 2010). A study by Ashman and Mascialino (2008) noted that deficits in encoding and retention of verbal information as well as inattention were more common and more serious post TBI in those over the age of 65 years. It has been postulated, for those who are older at the time of injury, that less neuronal plasticity may negatively affect the brain's ability to compensate or adapt in the same way a younger brain does post injury (Senathi-Raja et al., 2010).

Mosenthal et al. (2002) found older subjects (>64 years of age) had a significantly higher mortality rate than their younger peers at all levels of TBI severity ($p<0.001$). Study authors suggested this increase in mortality may be attributable to multiple factors including pre-existing comorbidities, post injury complications, and the intrinsic properties of aging itself (Mosenthal et al., 2002).

Evidently, for older patients with TBI, their recovery may be challenging; aging is often accompanied by a number of chronic comorbidities (e.g., diabetes, arthritis, cardiovascular disease and/or cerebrovascular disease) (Colantonio et al., 2011). Such factors are rarely taken into account when assessing the impact an ABI has on an older person (Colantonio et al., 2004; Rapoport & Feinstein, 2000); however, these pre-existing health issues may impede the recovery of patients living with an ABI if left unresolved.

A recent study examined the recovery of patients with TBI in inpatient rehabilitation facilities (Dijkers et al., 2013). The study found that adults aged 65 years or older had lower brain injury severity but more medical comorbidities than the younger participants. In addition, these older patients received fewer hours of therapy per day (especially from psychology and therapeutic recreation) and had shorter lengths of stay in both acute care and rehabilitation compared to the younger patients (Dijkers et al., 2013). Older TBI patients also showed less functional gains both during and after rehabilitation when compared with younger patients (Dijkers et al., 2013). Furthermore, older TBI patients had a higher death rate both 3 and 9 months post rehabilitation discharge than younger patients (Dijkers et al., 2013). Hence, issues regarding therapy intensity and care may be important when examining recovery among older adults.

2.1.3.2 Aging with an Established ABI

Few studies have examined the effects of ABI on life expectancy; however, it has been suggested that a person with TBI who recovers during the acute period may still have a substantially reduced life expectancy and a poorer outcome than those that do not have an ABI (Colantonio et al., 2009; Ratcliff et al., 2005). One of the strongest predictors of post-acute mortality is the patient's age at the time of injury, such that those of higher age have a higher risk of mortality in the acute phase of ABI (Colantonio et al., 2009). Further, Ratcliff et al. (2005) found an ABI doubled long-term mortality risk for all age groups, even though many survived 20 or more years post injury.

It is also important to consider that persons with TBI may be at risk for subsequent falls due to balance, mobility, and cognitive impairments, as well as environmental challenges such as building infrastructure. Coupled with the effects of aging, these risk factors may result in a patient sustaining yet another injury (Chan et al., 2013c). For more information on older age and ABI, please see Chapter 18.

2.1.4 The Impact of ABI on Survivors and the Healthcare System

Assessing the impact that an ABI may have on individuals as they age is difficult as survivors can live for several decades post injury. This is particularly true for children and adolescents who sustain an injury. Unfortunately, longitudinal studies assessing the impact of the injury on the individual and their families are challenging due to the cost, and the number of participants lost to follow-up.

Chen et al. studied direct costs – emergency department visit, acute care admission, inpatient rehabilitation stay, complex continuing care stay, home care services and physician visits – from the government payer's perspective for ABI patients discharged from Ontario acute care hospitals between 2004 and 2008. Total medical costs in the first year of follow up amounted to approximately $120.7 million for TBI patients and $368.7 million for nTBI patients; the most significant cost during the first year was the acute care stay. This translates into a mean cost during the first year of $32,132 per TBI patient and $38,018 per nTBI patient (Chen et al., 2012a). It is important to note that this study did not account for any indirect or directs costs to the patient or family such as lost income or out-of-pocket expenses. Most costs were incurred during the first follow up year; however, patients continued to require regular use of health care resources during the second and third year post ABI.

ABI is costly to the healthcare system, and unfortunately some costs are the result of alternative level of care (ALC) days. ALC is when patients occupy hospital beds even when they do not require the level of intensity of resources/services being provided in that particular care setting (Chen et al., 2012b) for example, this commonly occurs while patients are awaiting a placement in a long-term care facility. In Ontario, during fiscal years 2007/08 to 2009/10, the total number of days spent as ALC increased from 15,606 to 22,637 among TBI patients and from 39,918 to 48,267 among nTBI patients (Chen et al., 2012). This study also showed increased odds of having an ALC day was associated with increasing patient age, female sex, psychiatric comorbidity, and having been injured in an MVC.

Furthermore, the use of health care resources may also depend on multiple other factors. Fu et al. (2015) found, in Canada, there was a 29% increase in fall-related hospitalization rates among those aged 65 years or older with TBI between the years 2006 and 2011. Hammond et al. (2015) identified a 28% rehospitalization rate during the first 9 months following TBI rehabilitation discharge; older age at the time of injury, number of previous brain injuries, greater non-brain injury severity of illness score, and history of seizure before or during inpatient rehabilitation were all predictors of experiencing ≥1 rehospitalization. Rural residence and psychiatric comorbidity have also been shown to be predictors of rehospitalization (Saverino et al., 2016).

Unfortunately, data indicates that a large proportion of individuals with a brain injury do not appear to be accessing all the rehabilitation services that they need. The Ontario Brain Injury Association survey conducted in 2005 examined the number of individuals using services compared to those who weren't (OBIA, 2007). The main reasons given for the gaps between service need and use were long waiting lists, lack of available and appropriate services, lack of training about the cognitive and behavioural needs of patients, and poor coordination of services (Chen et al., 2012; Minnes et al., 2010). Of particular note is the apparent lack of access to services for psychological issues. Those with pre-existing comorbid conditions, such as psychosocial and psychiatric problems, are at an increased risk of mortality following injury (Colantonio et al., 2009); thus it is very important for patients to be able to access appropriate care in a timely manner.

2.1.5 Mortality and ABI

Individuals with ABI have lower life expectancies than matched individuals. Harrison-Felix et al. (2015) found that between 2001 and 2010, individuals with TBI were 2.23 times more likely to die compared to individuals similar in age, sex, and race; those patients with TBI had an average reduced life expectancy of 9 years. Older age, male sex, being unemployed at time of injury, being married at time of injury, and having less than a high school education have all been shown to be risk factors for earlier death among those with ABI (Cuthbert et al., 2015; Harrison-Felix et al., 2015). In a population of patients with severe TBI followed for the first 14 days post injury, mortality rates ranged from 24.5% among persons </= 65 years of age to 40.9% among persons >65 years of age (Walder et al., 2013). Fifty-four percent of adults over 55 years died within 6 months of discharge and 68% within 1 year (Peck et al., 2014).

2.2 Prognostic Indicators

It is important to know which factors are significantly related to outcomes post ABI. Prognostic indicators can include such variables as injury severity, etiology of injury, age, rehabilitation length of stay, duration of post-traumatic amnesia, etc. Table 2.1 summarizes the most common TBI prognostic indicators identified in the literature.

Table 2.1 Common Prognostic Indicators for ABI

• Age	• Rehabilitation length of stay
• Sex	• Duration of post-traumatic amnesia
• Presence of prior brain injury	• Timing of rehabilitation
• Injury severity	• Intensity of rehabilitation
• Length of coma	• Nature of injury (TBI versus nTBI)
• Initial Glasgow Coma Scale (GCS) score	• Presence of comorbidities
• Injury etiology	

Bushnik et al. (2003) studied a variety of etiologies, such as MVAs, assaults, and falls. They demonstrated that individuals involved in MVAs initially incurred more severe injuries than individuals injured by assaults, falls, or other causes. However, at one year post injury individuals with TBI related to MVAs reported the best functional and psychosocial outcomes, while individuals with violence-related TBI reported the highest unemployment rates and lowest Community Integration Questionnaire scores (Bushnik et al., 2003). Individuals with TBI related to falls or 'other' etiologies had outcomes that fell somewhere between those injured by MVAs and assaults. This occurred despite the fact there were no functional differences between the groups at discharge from rehabilitation.

Asikainen et al. (1998) focused on the effects of hospital admission Glasgow coma scale (GCS) score, length of coma, and duration of post-traumatic amnesia on outcomes post TBI. While hospital admission GCS score positively correlated with functional outcome as measured by Glasgow Outcome Scale scores, length of coma and duration of post-traumatic amnesia correlated with both functional and occupational outcomes. Poor scores on functional measures (e.g., mobility, eating, or grooming) have also been found to be significant predictors of premature death (Colantonio et al., 2008). Notably, limitation in eating was one of the most important predictors of mortality (Ratcliff et al., 2005).

The nature of the injury seems to play a predictive role in patient outcomes as well. For instance, Colantonio et al. (2011) reported that the diagnosis of nTBI was associated with a lower Functional Independence Measure rating at admission and at discharge, more comorbidity diagnoses, and longer lengths of stay in inpatient rehabilitation. Significantly more nTBI patients died in acute care, whereas more patients with TBI were discharged home, to inpatient rehabilitation, or to a long term care facility (Chan et al., 2013c).

The presence of comorbidities may affect patient outcome as well. Having a psychiatric comorbidity increased the odds of having an ALC day among patients with TBI by 73% (A. Y. Chen et al., 2012). Similarly, an increase in Charlson Comorbidity Index category increased the odds of having an ALC day by 9% in the TBI population. A study by Rapoport et al. (2000) demonstrated that major depression in older adults in the first months after TBI had persisting adverse effects on outcome. This finding is particularly problematic since studies have demonstrated that major depression is quite common in the TBI population, and associated with a poorer prognosis (Rogers & Read, 2007).

2.3 Long-Term Outcomes

There is increasing concern about the potential for development of neurodegenerative diseases many years after sustaining a TBI due to the physiological changes that occur following injury. The National Academy of Medicine (2008) has concluded that moderate and severe TBI is associated with the development of Alzheimer's and Parkinson's disease. Veterans that sustained a TBI were at an increased risk for Alzheimer's disease and dementia (Plassman et al., 2000). In individuals over the age of 55 years, this pattern was present even after a single presentation of moderate to severe TBI (Gardner et al., 2014). Furthermore, individuals that sustained a TBI were at an increased risk for Parkinson's disease, particularly with multiple TBIs (Goldman et al., 2006). Additional research is needed to further elucidate the relationship between TBI and the development of neurodegenerative diseases.

In an attempt to examine the long-term impact of ABI, some of the most salient studies related to long-term outcomes were identified and reviewed. Study follow-up periods ranged from three months to more than ten years. The studies included in the review below have been separated into two groups according to the participants' injury severity: 1) moderate to severe ABI (when both moderately and severely injured participants were included in the study) and 2) severe ABI (when only severely injured participants were included in the study). Studies were also separated according to three follow-up periods: 1) three months to two years, 2) three to five years, and 3) greater than five years. Results are summarized in Tables 2.2 to 2.4 below.

Table 2.2 Long-Term Outcomes Up to Two Years Post Injury

Author/ Year/ Country/ Study Design/ N	Study Summary
Moderate to Severe ABI	
Andersson et al. (2017) Sweden Cohort N=95	**Population**: 95 individuals with TBI, GCS ≤8 **Follow-up:** 1 yr and 10-15 yrs post injury **Findings:** There was no significant difference in GOS scores from 1 yr and 10-15 yr post ABI. Poorer GOS scores were correlated to age at both 1 yr ($p<0.001$), and 10-15 yr ($p=0.021$). At 10-15 yr follow-up 70% of patients reported mental fatigue. From first to second follow-up the TBI group had significantly higher rates of mortality ($p<0.001$, $p<0.001$) compared to healthy controls.
Novack et al. (2000) USA N=72	**Population**: 72 individuals with TBI; >50% severe injury. **Follow-up:** 6 and 12 mo post injury. **Findings:** For individuals with severe TBI, driving status improved only marginally from 6 mo (n=11) to 12 mo (n=16) ($p=0.05$); the total number of individuals with >20 hr/wk employment increased from 1 (2.0%) at 6 mo to 5 (10.2%) at 12 mo; and a trend towards increased productive activities was observed (8.2% at 6 mo vs. 16.8% at 12 mo, $p=0.04$).
Malec et al. (1993) USA N=29	**Population:** 29 individuals with ABI (TBI=20) participating in post-acute rehabilitation. Mean age at admission=33.1 yr; mean time post injury=1463.9 days. **Follow-up:** 1 yr (n=21). **Findings:** Eighty-six percent of patients were living with no supervision compared to 48% on admission. 48% of patients were in an independent work placement and 29% were unemployed.
Cope et al. (1991) USA N=145	**Population**: 145 individuals with ABI (TBI=113) admitted to post-acute rehabilitation; mean age=35 yr; mean time post injury=448 days; mean disability rating score=6.03. **Follow-up**: 6, 12, and 24 mo post discharge. **Findings:** From admission to follow-up there was an increase in residence at home (44.8% to 69.7%), an increase in competitive employment or academic involvement (5.6% to 34.5%), a decrease in 'no productive activity' (92.3% to 27.6%), and an increase in the percentage of patients independent throughout a 24 hr period (25% to. 78.6%). All differences were significant ($p<0.0001$).
Severe ABI	
Harrick et al. (1994) Canada N=21	**Population:** 21 individuals with severe TBI. **Follow-up**: 1 yr. **Findings**: Upon discharge 62% (vs. 34% at admission) were engaged in productive activity. Financially 10% (vs. 5% at admission) were self-supported, 24% (vs. 5% at admission) were both self-supported and aided, and 62% (vs. 81% at admission) were aided. Moreover, 81% (vs. 68% at admission) received informal support, 19% (vs. 10% at admission) received partial support, and no one (vs. 24% at admission) required institutional support.
Mills et al. (1992) USA N=42	**Population:** 42 patients with TBI; GCS score <9. **Follow-up:** 6 mo (n=32), 12 mo (n=13), and 18 mo (n=18) post discharge from a community cognitive rehabilitation program. **Findings:** At 6 mo follow-up, 87.5% of patients maintained or improved their status in the home and community, and 90% maintained or improved their status in leisure and vocational function. These gains were maintained or improved at a follow-up of 12 and 18mo.

Table 2.3 Long-Term Outcomes at Three to Five Years Post Injury

Author/ Year/ Country/ Study Design/ N	Study Summary
Severe ABI	
Odgaard et al. (2017) Denmark N=3134	**Population:** 3134 patients with severe TBI. **Follow-up:** 2 yr and 5 yr post TBI **Findings:** The majority of return to work occurred within the first year post TBI, at 5 yr follow-up 70% of patients were receiving public assistance benefits.

Author/ Year/ Country/ Study Design/ N	Study Summary
Katz et al. (2009) USA N=36	**Population:** 36 patients with ABI (TBI=22). **Follow-up:** 2 yr and 4 yr. **Findings:** Of 16 patients who were assessed at 2 yr follow-up, Disability Rating Scale (DRS) scores continued to improve compared to admission in 56% of patients. Between 2 yr and 4 yr, improvement was seen in 3 of 8 patients. Of 23 patients followed 1 to 4 yr, 43% achieved household independence, and 22% returned to work or school.
Kaitaro et al. (1995) Finland N=19	**Population:** 19 patients with severe TBI. **Follow-up:** 5 yr. **Findings:** None of the participants required institutional care. Sixty-eight percent of patients were living with their families or spouses. Eighty-nine percent of patients were retired despite attempts to work.
Harrick et al. (1994) Canada N=21	**Population:** 21 individuals with severe TBI. **Follow-up:** 3yr. **Findings:** At discharge, 67% (vs. 34% at admission) were engaged in productive activity. Financially, 15% (vs. 5% at admission) were self-supported, 15% (vs. 5% at admission) were both self-supported and aided, and 73% (vs. 81% at admission) were aided. Moreover, 77% (vs. 68% at admission) received informal support, 24% (vs. 10% at admission) received partial support, and no one (vs. 24% at admission) required institutional support.

Table 2.4 Long-Term Outcomes at Greater than Five Years Post Injury

Author/ Year/ Country/ Study Design/ N	Study Summary
Moderate to Severe ABI	
Andersson et al. (2017) Sweden Cohort N=95	**Population**: 95 individuals with TBI, GCS ≤8 **Follow-up:** 1 yr and 10-15 yr post injury **Findings:** There was no significant difference in GOS scores from 1yr and 10-15yr post ABI. Poorer GOS scores were correlated to age at both 1 yr ($p<0.001$), and 10-15 yr ($p=0.021$). At 10-15 yr follow-up, 70% of patients reported mental fatigue. From first to second follow-up, the TBI group had significantly higher rates of mortality ($p<0.001$, $p<0.001$) compared to healthy controls.
Klonoff et al. (2001) USA N=164	**Population:** 164 patients with ABI (TBI=113). **Follow-up:** 11 yr. **Findings**: At follow-up, 83.5% were productive in some capacity; 46.3% were gainfully employed full-time, 11.6% were in full-time school or school/work, 9.2% were in part-time gainful work or school, and 12.2% worked as volunteers. 16.5% were not productive in any capacity. Additionally, younger age ($p=0.009$), being male ($p=0.025$), and higher staff working alliance ratings of patients ($p=0.024$) and their families ($p=0.017$) were associated with better vocational/school outcomes.
Severe ABI	
Author/ Year/ Country/ Study Design/ N	**Study Summary**
Possl et al. (2001) Germany N=43	**Population**: 43 participants with severe ABI. **Follow-up:** 7-8yr. **Findings:** At follow-up, 37% had achieved stable re-employment at pre injury levels, 16% had achieved stable re-employment with work modifications, 19% continued to have persistent vocational adjustment problems, and 28% opted for retirement.
Johnson (1998) UK N=64	**Population:** 64 patients with severe head injury. **Follow-up:** 10 yr or more. **Findings:** At follow-up, 42% had re-established employment, 20% had an irregular pattern of work, and the remainder were not in the workforce.

Wilson (1992) UK N=25	**Population:** 25 patients. **Follow-up:** 5-10 yr. **Findings:** At follow-up, 81% were living in their own homes either alone, with relatives, or with friends. Those remaining were in long-term residential care, residential college, or warden controlled accommodation. 42% were in paid employment; 1 of 11 were in paid employment that was comparable to their pre injury status.

Table 2.5 summarizes whether each long-term outcome study reported a positive or negative outcome regarding participants' productivity, independence, and place of residence. Productivity outcomes were defined as positive if the majority (≥50%) of participants were involved in any form of paid or unpaid labour, including volunteer work. If the majority of participants were not taking part in any of the aforementioned types of productive activity (e.g. they were retired) then it was considered a negative outcome**.** Independence was related to the level of supervision required. A positive outcome was noted as long as the majority of participants did not require institutional care or support. However, if the majority of participants did require this type of assistance, it was deemed a negative outcome. Positive place of residence outcomes were noted when the majority of participants in the study were not living in an institutionalized setting. Otherwise, it was considered to be a negative outcome. Positive trends and increases regarding productivity, independence, and place of residence were also viewed as positive outcomes.

Table 2.5 Long-Term Outcomes for Productivity, Independence, and Place of Residence

Author/Year/ Country	Injury Severity	Follow-Up Period	Productivity	Independence	Place of Residence
Cope et al. (1991) USA	moderate to severe ABI	3 mo-2 yr	+ (no deterioration in positive trends from 6-24 mo)	+ (no deterioration in positive trends from 6-24 mo)	+ (no deterioration in positive trends from 6-24 mo)
Malec et al. (1993) USA	moderate to severe ABI	3 mo-2 yr	+ (72%)	+ (96%)	n/a
Klonoff et al. (2001) USA	moderate to severe ABI	>5 yr	+ (83.5%)	n/a	n/a
Novack et al. (2000) USA	severe ABI	3 mo-2 yr	+ (12.6% increase in those involved in productive activity from 6-12mo)	n/a	n/a
Mills et al. (1992) USA	severe ABI	3 mo-2 yr	+ (90%)	n/a	n/a
Harrick et al. (1994) Canada	severe ABI	3 mo-2 yr	+ (62%)	+ (100%)	+ (100%)
Harrick et al. (1994) Canada	severe ABI	3-5 yr	+ (67%)	+ (100%)	+ (100%)
Kaitaro et al. (1995) Finland	severe ABI	3-5 yr	- (89%)	n/a	+ (100%)

Author/Year/ Country	Injury Severity	Follow-Up Period	Productivity	Independence	Place of Residence
Wilson (1992) UK	severe ABI	>5 yr	- (42%)	+ (81%)	+ (81%)
Johnson (1998) UK	severe ABI	>5 yr	+ (62%)	n/a	n/a

Note: +=positive outcome; -=negative outcome; n/a=not applicable; (%)=Percentage of participants who experienced positive/negative outcome.

2.4 Conclusions

In summary, although methodological differences between studies exploring the long-term outcomes post ABI do not permit direct comparison, it is generally true that those who have moderate to severe ABI appear to fare better than those with exclusively severe ABI; this was particularly true when looking at the dimension of productivity. In terms of employment, approximately 40% of those with severe TBI were able to return to employment at 7-10 years post TBI (Johnson & Davis, 1998; Possl et al., 2001). This is in comparison to those with moderate TBI where over 60% were in full-time positions either at work or school 11 years post TBI (Klonoff et al., 2001). However, even those with severe ABI might expect to have generally favorable outcomes with respect to return to independent living.

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