June 2009

The economic cost of spinal cord injury and traumatic brain injury in Australia

Report by Access Economics Pty Limited for

The Victorian Neurotrauma Initiative

FOREWORD

Traumatic brain and spinal cord injury are debilitating injuries that have a life-long impact on the injured person. Aside from the physical impact of these injuries, many aspects of daily function are affected, including the ability to work and take part in social and community activities. Neurotrauma most commonly occurs in young adults involved in transport accidents. Advances in treatment have led to a reduction in mortality, meaning that an increasing majority of those affected are living with the consequences of brain or spinal cord injury for decades following injury.

In 2005, the Victorian government recognised the need to enhance understanding of these injuries, and to develop more effective treatments and interventions, by establishing the Victorian Neurotrauma Initiative (VNI) health and medical research fund. Through the VNI, the Transport Accident Commission and the state government seek to reduce the burden of neurotrauma in the state. Outcomes arising from VNI-funded research will also be of benefit nationally and internationally.

Despite rapidly increasing knowledge of the biological, physical, emotional and social impact of brain and spinal cord injury, our understanding of the economic impact of neurotrauma has been limited. The VNI commissioned this report from Access Economics to enhance our knowledge in this area. Whilst TBI/SCI are relatively uncommon injuries, patients are typically injured at a young age and are disabled for the remainder of their lives, leading to very high costs. The lifetime cost of new cases of brain and spinal cord injury occurring in 2008 alone is $10.5 billion in Australia. The largest cost is attributed to burden of disease, direct costs such as provision of attendant care and healthcare services are also significant.

At the level of the individual, the economic impact of these injuries is comparable to or greater than that of diseases commonly considered to be ‘high-cost’, including other neurological conditions. Neurotrauma has a huge impact on society and on the affected individual.

This report also delivers some good news. Two interventions for improving the lives of those affected by neurotrauma are shown to be cost-effective. The report demonstrates that routine use of saline to resuscitate individuals with traumatic brain injury (as opposed to albumin) would significantly reduce mortality associated with traumatic brain injury in Australia. In quadriplegia, use of continuous positive airway pressure to treat sleep disorders such as apnoea would also reduce the burden of disease for a cost well within benchmarks of acceptability.

Both studies received funding from the VNI and TAC in addition to funding from other government agencies. This demonstrates the vital role that the VNI plays in improving the quality of life of those impacted by neurotrauma.

Dr Alex Collie

Director, Victorian Neurotrauma Initiative

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ACKNOWLEDGEMENTS

This report was prepared by Access Economics for the Victorian Neurotrauma Initiative (VNI). The VNI is a health research fund that supports research into traumatic brain injury (TBI) and spinal cord injury (SCI) conducted by Victorian scientists in collaboration with national and international colleagues. The VNI is a wholly owned subsidiary of the Transport Accident Commission (TAC) and receives support from the Victorian Department of Innovation, Industry and Regional Development.

Access Economics would like to acknowledge with gratitude the advice and assistance from the expert panel convened for this project comprising:

- Professor Doug Brown, Director Victorian Spinal Cord Service, Austin Hospital;
- Dr Alex Collie, Director, Victorian Neurotrauma Initiative;
- Professor Jamie Cooper, Deputy Director Intensive Care Unit, Alfred Hospital;
- Dr Belinda Gabbe, Department of Epidemiology and Preventive Medicine, Monash University;
- Ms Francene McCartin, Assistant Director Disability Services Division, Department of Human Services;
- Professor John Olver, Director Brain Injury Rehabilitation, Epworth Hospital; and
- Mr Peter Trethewey, Chief Executive Officer, AQA (Australian Quadriplegic Association) Victoria Ltd.

Access Economics also wishes to acknowledge with thanks the organisations and individuals who provided data and information upon request for this project.

- **Transport Accident Commission (TAC).** The TAC is a Victorian Government-owned organisation whose key role is to pay for treatment and benefits for people injured in transport accidents in Victoria. The TAC provided detailed data on the costs for healthcare, long term care, equipment and modifications, administration and compensation to families for TBI and SCI patients in Victoria.
- **Victorian State Trauma Registry (VSTR).** The VSTR is managed by the Victorian State Trauma Outcome Registry and Monitoring (VSTORM) group in the Department of Epidemiology and Preventive Medicine at Monash University. The VSTR collects data for all hospitalised major trauma patients in Victoria according to specified inclusion criteria. Upon request, the VSTR provided incidence, mortality and health outcome data relating to TBI and SCI for Victoria.
- **Department of Human Services (Victoria) – Metropolitan Health & Aged Care Services Division.** Metropolitan Health & Aged Care Services Division is responsible for the full range of health and aged care services in metropolitan Melbourne. Data were provided on the frequency, mean length and cost of acute hospital separations stratified according to funding type for TBI patients.
- **Department of Human Services (Victoria) – Disability support.** Disability Services is a division of the Department of Human Services (DHS) whose role is to fund providers across the non-government sector to provide direct support and care for

people with an intellectual, physical, sensory or neurological disability, or an acquired brain injury in Victoria. Data were provided on carers, independence in activities of daily living, disability services and employment for Victorians with acquired brain injury.

- **Australasian Rehabilitation Outcomes Centre (AROC).** The AROC is a joint initiative of the Australian rehabilitation sector (providers, funders, regulators and consumers). The AROC provided data on funding sources for TBI/SCI patients and support required pre and post injury.
- **Centrelink**. Centrelink is an Australian Government statutory agency, delivering a range of Commonwealth services to the Australian community. Centrelink provided the number of Australians with TBI who received the Disability Support Pension.
- **New South Wales Spinal Cord Injury Service (NSW SCIS)**. NSW SCIS provides services to people with SCI in NSW to facilitate independence and achievement of personal goals. Data were provided on the incidence of SCI in NSW and healthcare utilisation for SCI patients.
- **Queensland Trauma Registry (QTR).** The QTR is the lead program of the Centre of National Research on Disability and Rehabilitation Medicine in the University of Queensland. Data were provided on the incidence of TBI/SCI and healthcare utilisation of TBI/SCI patients in Queensland.

In addition, Access Economics wishes to acknowledge with thanks the advice and information provided by the following organisations.

- **Health Information Services, Austin Hospital (Melbourne).** Advice was provided relating to the ICD-10 codes relating to SCI.
- **National Injury Surveillance Unit (NISU) at Flinders University.** NISU is the collaborating unit of the Australian Institute of Health and Welfare (AIHW) in the subject area of injury. NISU provided advice regarding availability of incidence and prevalence data for TBI/SCI in Australia, methodological challenges for incidence estimates and data limitations.
- **Dr Duncan Mortimer,** Health Economist on Sleep Health in Quadriplegia study, University of South Australia. Dr Mortimer provided background and description of the SHiQ program. He also recommended options for completing the cost effectiveness analysis (CEA).
- **Professor John Myburgh,** author of Myburgh et al (2008) 'Epidemiology and 12-Month Outcomes From Traumatic Brain Injury in Australia and New Zealand'. Professor Myburgh provided previously unpublished mortality rates for TBI.
- **ABS Survey of Disability and Carers (SDAC).** The SDAC is a survey and publication covering information on people with a disability, older people (i.e. those aged 60 years and over) and people who provide assistance to older people and people with disabilities. Data were provided on primary informal carers and aids and modifications for people with TBI and SCI.

Finally, Access Economics wishes to acknowledge with thanks the provision of publicly available data sets.

- **Commonwealth State/Territory Disability Agreement National Minimum Data Set (CSTDA NMDS).** The CSTDA NMDS is administered by the AIHW and is contained on the AIHW website to provide interested people and organisations with up-to-date information on disability support services. Data were retrieved on employment status, requirement for carer support and assistance with activities of daily living for people with acquired brain injury.
- **National Hospital Morbidity Database (NHMD).** The NHMD is published by the AIHW and is a collection of electronic confidentialised summary records for separations (episodes of care) in public and private hospitals in Australia. Data on the number of separations disaggregated by age and sex, mean length of stay and for ICD-10 codes associated with TBI and SCI were retrieved.

ACRONYMS

ABS	Australian Bureau of Statistics
AHI	Apnea-Hypopnea Index
AIHW	Australian Institute of Health and Welfare
ALOS	average length of stay
ASCIR	Australian Spinal Cord Injury Register
ARDRG	Australian Refined Diagnosis Related Group
AROC	Australasian Rehabilitation Outcomes Centre
AWE	Average weekly earnings
BoD	Burden of Disease
CEA	Cost effectiveness analysis
CPAP	Continuous positive airway pressure
CSTDA NMDS	Commonwealth State/Territory Disability Agreement National Minimum Data Set (AIHW)
DALY	Disability Adjusted Life Year
DHS	Department of Human Services (Victoria)
DSQDC	Disability Service Quarterly Data Collection Information System
DWLs	Deadweight losses
ED	Emergency department
ESS	Epworth sleepiness scale
GCS	Glasgow Coma Scale
GDP	Gross domestic product
GOS-E	Glasgow Outcome Scale (Extended)
GP	General practitioner
ICD(-10)	International Classification of Disease (tenth revision)
ICU	Intensive care unit
LOE	Loss of earnings
NHMD	National Hospital Morbidity database (AIHW)
NISU	National Injury Surveillance Unit
NPV	Net present value
NSW SCIS	New South Wales Spinal Cord Injury Service
OR	Odds ratio
OSA	Obstructive sleep apnoea
PBS	Pharmaceutical Benefits Schedule
PTA	Post-traumatic amnesia
QALY	Quality Adjusted Life Year
QSCIS	Queensland Spinal Cord Injuries Service
QTR	Queensland Trauma Registry
RR	Relative risk
SCI	Spinal cord injury

SDAC	Survey of Disability Ageing and Carers (ABS)
SMR	Standardised mortality rate
TAC	Transport Accident Commission
TBI	Traumatic brain injury
UK	United Kingdom
VNI	Victorian Neurotrauma Initiative
VSL(Y)	Value of a Statistical Life (Year)
VSTORM	Victorian State Trauma Outcome Registry and Monitoring
VSTR	Victorian State Trauma Registry
WTP	Willingness to pay
YLD	Year of healthy life Lost due to Disability
YLL	Year of Life Lost due to premature mortality

EXECUTIVE SUMMARY

This report was prepared by Access Economics for the Victorian Neurotrauma Initiative (VNI), with oversight from a steering group of neurotrauma researchers, clinicians representing the major spinal cord injury (SCI) and traumatic brain injury (TBI) hospitals in Victoria, a disability services organisation supporting people with SCI and the Department of Human Services (DHS) Victoria. The objectives of the project were to:

1 determine the economic impact of TBI and traumatic SCI in Victoria and Australia;

2 estimate the burden of disease of TBI and SCI in Victoria and Australia;

3 compare the economic impact and disease burden of TBI and SCI with other conditions; and

4 model the potential impact of improved TBI and SCI management strategies on the economic cost and burden of disease (cost effectiveness analysis).

Traumatic brain injury (TBI) refers to brain injury acquired through a traumatic event, such as a traffic accident or a blow to the head (AIHW, 2008). The leading causes of TBI in Australia are transport accidents, falls, collisions with objects and water related accidents. TBI can be categorised as mild, moderate and severe. Mild TBI was excluded from this analysis.

TBI can cause long-term physical disability and complex neuro-behavioural effects which disrupt quality of life, including neurological impairment (e.g. motor function impairment and sensory loss), medical complications (e.g. spasticity and post-traumatic epilepsy), cognitive impairment (e.g. memory impairment and problems with planning, language and safety awareness), personality and behavioural changes (e.g. impaired social and coping skills) and lifestyle consequences (e.g. unemployment, difficulty maintaining interpersonal relationships and loss of independence).

Spinal cord injury (SCI) refers to an acute, traumatic lesion of neural elements in the spinal canal resulting in temporary or permanent sensory deficit, motor deficit or bladder/bowel dysfunction (AIHW, 2007). The leading causes of SCI in Australia are transport accidents, falls and water related accidents. This analysis is limited to paraplegia and quadriplegia from traumatic causes.

SCI can cause long-term physical disability and complex complications which disrupt quality of life, including limitations in mobility (e.g. approximately 60% of chronic SCI patients are wheelchair dependent), problems in social functioning (e.g. poor access to transportation leads to fewer social opportunities), psychological complications (e.g. depression may occur and life satisfaction may be adversely affected), medical complications (e.g. urinary tract infections, bacterial infections and pressure ulcers are common) and sleep issues (e.g. there is a high prevalence of obstructive sleep apnoea in SCI patients).

Costing approach

An incidence based costing approach was employed, measuring the number of new cases of TBI/SCI in the base period (calendar year 2008) and the costs associated with treatment, as well as other financial and non-financial costs (e.g. productivity losses, loss of quality of life) over the person's lifetime, due to SCI/TBI. An incidence approach was nominated to best link into the cost effectiveness analyses (CEA) and due to availability of data.

Estimated incidence

Incidence estimates for SCI in Australia were based on data retrieved from the Australian SCI register reported by the National Injury Surveillance Unit (NISU) at Flinders University. Incidence estimates for TBI were based on incidence rates calculated for Victoria[1] (see methodology below) applied to the Australian population. For the year 2008 in Australia there were an estimated:

- 1,493 new cases of moderate TBI and 1,000 new cases of severe TBI; and
- 137 new cases of paraplegia and 136 new cases of quadriplegia.

For Victoria, the Victorian State Trauma Registry (VSTR) provided data on the number of new cases of TBI/SCI meeting registry entry criteria for 2007-08. The VSTR does not capture all cases of moderate TBI therefore, the number of new cases were estimated based on the ratio of moderate to severe TBI cases (1.48:1) reported by Tate (1998). For 2008 in Victoria, there were an estimated:

- 370 new cases of moderate TBI and 248 new cases of severe TBI; and
- 36 new cases of paraplegia and 52 new cases of quadriplegia.

Mortality rates

Mortality data from recent Australian studies showed that most of the deaths attributable to TBI/SCI occur in the first 12 months post injury. Thus in the modeling, higher than average mortality rates were applied for the first year after injury only, and population average mortality rates were applied to people surviving longer than one year. Mortality rates in the year after injury were:

- 22.6% for moderate TBI and 35.1% for severe TBI; and
- 6.4% for paraplegia and 13.7% for quadriplegia.

Healthcare, long term care and equipment/modifications costs

Healthcare, long term care and equipment/modifications costs were based on compensation data from the Transport Accident Commission (TAC) Victoria. There were marked trends in costs over time post injury. For example, for severe TBI and quadriplegia, mean healthcare costs decreased in the first six years while long term care costs increased over the same time period. These trends were captured in the cost model. Several issues regarding the transferability of Victorian TAC compensation costs to TBI/SCI patients across Australia were resolved based on parameters derived from various sources.

- Some 36.8% of Australian and 52.0% of Victorian TBI/SCI cases were compensable under either 'no fault' or common law transportation accident schemes.
- Rehabilitation/long term healthcare costs, equipment/modifications and long term care costs were decreased by 30% for non-compensable patients.
- Victorian unit cost data were broadly transferable to other Australian jurisdictions.
- TAC costs (for transport injuries) were transferable to similar injuries from other causes.

[1] 7.0 and 4.7 cases per 100,000 persons for moderate and severe TBI respectively.

Health system expenditures include administration, ambulance/road accident rescue, hospital, medical and paramedical costs. TAC unit hospital costs were reduced by 30% for half of TBI/SCI patients, to reflect treatment of co-morbidities in these people.

Equipment and modifications include equipment and technology to assist with daily living and transportation, avoid medical complications, and provide home assistance or ventilation.

Long term care costs tend to be very high for TBI and SCI, including items such as assisted accommodation, respite care, personal assistance, supported community services and living expenses.

COST ITEMS BASED ON TAC DATA ($ MILLION)

	Moderate TBI	Severe TBI	Paraplegia	Quadriplegia	Total TBI/SCI
Australia					
Health System	269.1	308.0	52.5	76.5	**706.1**
Aids/equipment	59.7	158.5	113.2	113.6	**445.0**
Long term care	300.0	962.5	109.4	500.7	**1,872.7**
Total	**628.9**	**1,429.0**	**275.1**	**690.9**	**3,023.8**
Victoria					
Health System	66.7	76.1	13.5	24.7	**181.1**
Aids/equipment	15.6	41.4	30.4	36.5	**123.9**
Long term care	78.4	250.7	29.3	155.1	**513.4**
Total	**160.8**	**368.1**	**73.2**	**216.3**	**818.4**

Source: TAC (2009) and Access Economics.

Productivity costs and other financial costs

Productivity costs include lost production (using a human capital approach) due to:

- lower re-employment after injury – average employment rates for patients with TBI and SCI were calculated as approximately 50% of general population employment rates based on findings from published literature. The costs were estimated using Australian Bureau of Statistics data on average weekly earnings (AWE);
- higher absenteeism (sick days) from paid work – estimated as five days for all TBI/SCI patients where either employer-paid sick leave is taken or the individuals draw down their own funds;
- reduced domestic productivity – based on the same assumptions as absenteeism from paid work, but with domestic absenteeism valued at 30% of AWE;
- premature death – where remaining lifetime earnings lost are calculated based on premature mortality due to TBI/SCI and AWE, plus a bring-forward of search and hiring costs for replacement workers.

Carer costs were estimated using an opportunity cost approach measuring the hours of informal (unpaid) care based on data from the ABS Survey of Disability Ageing and Carers (SDAC), the Victorian Disability Service Quarterly Data Collection Information System, the AIHW Commonwealth State/Territory Disability Agreement National Minimum Data Set, Access Economics (2005) and other literature, to estimate the proportion of individuals who had a carer and the total number of hours of care provided to people with TBI and SCI in

2008. The value of care was then calculated based on AWE and the average probability of employment of the carer.

Deadweight losses (DWLs) were calculated as efficiency losses from taxation revenue forgone and from welfare transfers. **Other costs** were the bring-forward of funeral costs and were minor.

PRODUCTIVITY AND OTHER FINANCIAL COSTS ($ MILLION)

	Moderate TBI	Severe TBI	Paraplegia	Quadriplegia	Total TBI/SCI
Australia					
Lower employment	452.9	256.3	47.8	43.8	800.8
Premature death	243.4	253.3	6.8	14.3	517.8
Other productivity losses	1.8	1.2	0.2	0.2	3.5
Subtotal productivity costs	*698.1*	*510.8*	*54.7*	*58.4*	*1,322.0*
Carers	25.1	28.5	9.1	14.6	77.3
Other	0.7	0.7	0.0	0.0	1.5
DWLs	174.6	150.5	30.0	41.5	396.6
Total	***898.5***	***690.5***	***93.9***	***112.6***	***1,797.4***
Victoria					
Lower employment	119.0	70.5	12.5	12.7	214.7
Premature death	63.7	69.4	1.8	4.1	139.0
Other productivity losses	0.6	0.4	0.1	0.1	1.1
Subtotal productivity costs	*183.3*	*140.3*	*14.3*	*16.9*	*354.9*
Carers	6.6	7.5	2.4	4.8	21.3
Other	0.2	0.2	0.0	0.0	0.4
DWLs	36.8	38.2	6.0	9.1	90.2
Total	***226.9***	***186.2***	***22.8***	***30.8***	***466.7***

Source: Access Economics.

Burden of disease

Disability weights adopted for this analysis were 0.193 and 0.429 for moderate and severe TBI respectively and 0.570 and 0.840 for paraplegia and quadriplegia respectively. In total, the burden of disease was estimated to be around 36,133 disability adjusted life years (DALYs) for all patients with TBI and SCI in Australia. Multiplying the number of DALYs by the VSLY ($157,795) provides an estimate of the dollar value of the loss of wellbeing due to TBI and SCI.

BURDEN OF DISEASE (DALYS AND $ MILLION)

	Moderate TBI	Severe TBI	Paraplegia	Quadriplegia	Total TBI/SCI
Australia					
DALYs	13,398	17,060	2,032	3,058	36,133
$m	2,206.6	2,691.9	320.7	482.5	5,701.7
Victoria					
DALYs	3,539	4,299	520	954	9,313
$m	558.5	678.4	82.1	150.6	1,469.5

Source: Access Economics.

Summary of cost results for Australia

The total cost of **TBI** in Australia was estimated to be $8.6 billion, comprising:

- costs attributable to moderate TBI ($3.7 billion) and severe TBI ($4.8 billion);
- financial costs ($3.7 billion) and burden of disease costs ($4.9 billion); and
- the greatest portions borne by individuals (64.9%), the State Government (19.1%) and Federal Government (11.2%).

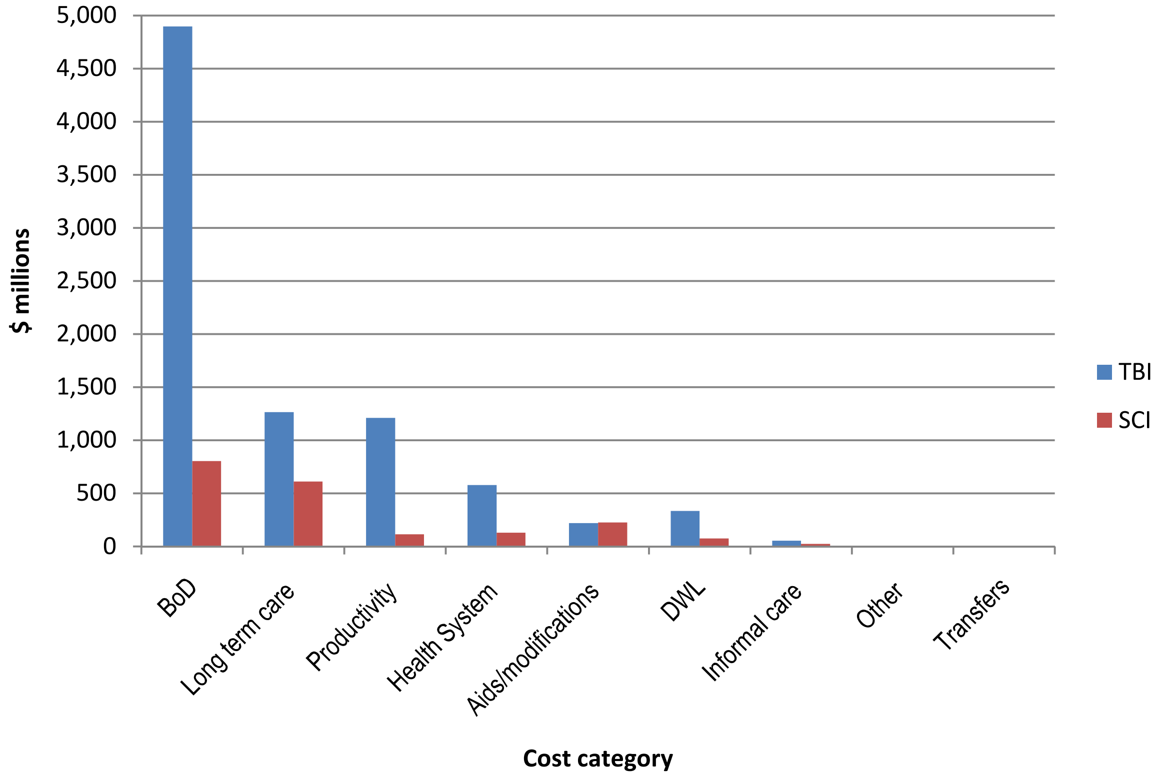
The lifetime costs per incident case of TBI were estimated to be $2.5 million and $4.8 million for moderate TBI and severe TBI respectively, across Australia.

The total cost of **SCI** in Australia was estimated to be $2.0 billion, comprising:

- costs attributable to paraplegia ($689.7 million) and quadriplegia ($1.3 billion);
- financial costs ($1.2 billion) and burden of disease costs ($803.2 million); and
- the greatest portions borne by the State Government (44.0%), individuals (40.5%) and the Federal Government (10.6%).

The lifetime cost per incident case of SCI was estimated to be $5.0 million per case of paraplegia and $9.5 million per case of quadriplegia, across Australia.

COST OF TBI/SCI INCIDENT CASES IN 2008 BY COST CATEGORY, AUSTRALIA, SORTED BY MAGNITUDE



Source: Access Economics calculations. The costs are the net present value of lifetime costs that result from incident cases in one year.

The total cost of TBI and SCI combined in Australia was estimated to be $10.5 billion.

Results for Victoria

The total cost of **TBI** in Victoria was estimated to be $2.2 billion, comprising:

- costs attributable to moderate TBI ($946.2 million) and severe TBI ($1.2 billion);
- financial costs ($942.1 million) and burden of disease costs ($1.2 billion); and
- the greatest portions of cost borne by individuals (66.8%), the State Government (19.2%) and Federal Government (9.7%).

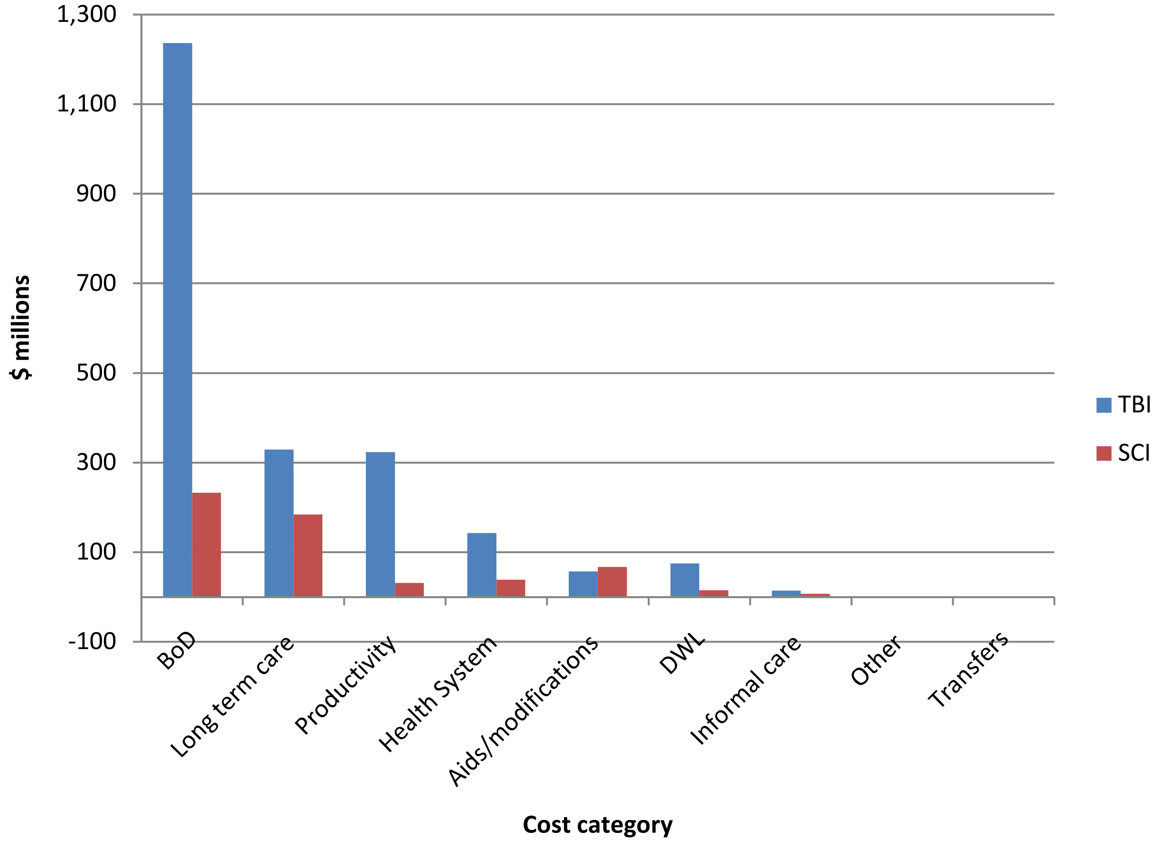
The lifetime costs per incident case of TBI were estimated to be $2.6 million and $5.0 million for moderate TBI and severe TBI respectively in Victoria. Cost differed due to the higher proportion of compensable patients in Victoria.

The total cost of **SCI** in Victoria was estimated to be $575.8 million, comprising:

- costs attributable to paraplegia ($178.1 million) and quadriplegia ($397.7 million);
- financial costs ($343.1 million) and burden of disease costs ($232.7 million); and
- the greatest portions borne by the State Government (45.2%), individuals (44.3%) and the Federal Government (6.8%).

The lifetime costs per incident case of SCI were estimated to be $4.9 million and $7.6 million for paraplegia and quadriplegia respectively in Victoria.

COST OF TBI/SCI OF INCIDENT CASES IN 2008 BY COST CATEGORY, VICTORIA, , SORTED BY MAGNITUDE



Source: Access Economics calculations. The costs are the net present value of lifetime costs that result from incident cases in one year.

The total cost of TBI and SCI combined in Victoria was estimated to be $2.8 billion.

Comparison with other conditions

The financial cost per case per year of TBI and SCI was compared with other conditions i) with a similar epidemiology[2], ii) similar incidence and ii) similar causal mechanism.

- Costs for TBI were higher than all comparator conditions[3], except muscular dystrophy.
- Costs for SCI were higher than all comparator conditions.

[2] TBI/SCI patients are typically injured at a young age (late adolescence and early adulthood) and are disabled for the remainder of their lives.

[3] Included Muscular Dystrophy, Cerebral Palsy, Dementia, Multiple Sclerosis, Bipolar disorder, Crohn's Disease, Ulcerative Colitis and Workplace Injury.

Cost effectiveness analysis

Two cost effectiveness analyses (CEAs) were undertaken.

1. Albumin versus saline used in fluid resuscitation for severe TBI patients

A randomised controlled trial demonstrated that severe TBI patients resuscitated using saline have a lower mortality rate (18.4 percentage points lower within 12 months) than those resuscitated using albumin (SAFE study investigators, 2007). Therefore, productivity losses and burden of disease due to premature death could be avoided with the use of saline instead of albumin — although longer survival will also lead to higher healthcare costs. In addition, the cost of saline ($1.60/litre) was substantially lower than that of albumin ($332.11/litre).

The CEA demonstrated that use of saline was both less costly (in terms of treatment, productivity and other costs) and avoided more DALYs than albumin. The use of saline in fluid resuscitation for severe TBI patients was thus found to be dominant[4].

2. CPAP treatment versus no CPAP for patients with quadriplegia and sleep apnoea

Continuous positive airway pressure (CPAP) (a machine worn to assist breathing during sleep) is a common treatment for patients with both quadriplegia and obstructive sleep apnoea (OSA). OSA is more common among people with quadriplegia than among the average population. Taking into account compliance rates with therapy, CPAP treatment costs were compared with the benefits from improved sleep outcomes, specifically, reduced mortality associated with cardiovascular events (Access Economics, 2005; Doherty et al, 2005). The comparator was no intervention for OSA.

The incremental cost effectiveness ratio (ICER) associated with providing CPAP to treat OSA in patients with quadriplegia was $16,037/DALY avoided - less than the $60,000/QALY threshold indicated by DoHA (2003) and 'very cost effective' according to the WHO standard (less than GDP per capita/DALY averted).

Access Economics
May 2009

[4] Economic classification for interventions which both save costs and generate health benefits.

1. INTRODUCTION

This report was prepared by Access Economics for the Victorian Neurotrauma Initiative (VNI). In addition to representatives of the VNI, this project was overseen by a steering group consisting of neurotrauma researchers, clinicians representing the major spinal cord injury (SCI) and traumatic brain injury (TBI) hospitals in Victoria, a disability services organisation supporting people with SCI and the Department of Human Services (DHS) Victoria.

1.1 AIM AND DELIVERABLES

The objectives of this project were to:

1. determine the economic impact of TBI and traumatic SCI in Victoria and Australia;
2. estimate the burden of disease of TBI and SCI in Victoria and Australia;
3. compare the economic impact and disease burden of TBI and SCI to other conditions; and
4. model the potential impact of improved TBI and SCI management strategies on the economic cost and burden of disease (cost effectiveness analysis).

1.2 STRUCTURE OF THIS REPORT

- Chapter 2 describes TBI and SCI including definitions, cause of injury, morbidity, mortality, healthcare utilisation and estimates the incidence for Australia and Victoria.
- Chapter 3 describes cross-cutting methodological issues.
- Chapter 4 describes the common methodology for the calculation of healthcare costs long term care costs and costs for equipment and modifications which is based on cost data from the Transport Accident Commission (TAC) in Victoria.
- Chapter 5 estimates the direct health system costs of TBI and SCI in Australia and Victoria, based primarily on data from TAC.
- Chapter 6 provides basic estimates of other financial costs, including lost productivity, carer costs, long term care cost, costs for equipment and modifications for Australia and Victoria.
- Chapter 7 estimates the burden of disease, measured in terms of disability adjusted life years (DALYs), of TBI and SCI in Australia and Victoria, disaggregated by the mortality component (years of life lost due to premature death – YLL) and the morbidity component (years of life lost due to disability – YLD), converted into a reasonable monetary equivalent.
- Chapter 8 summarises all costs and compares the economic impact and disease burden of TBI and SCI to other neurological conditions and conditions with similar incidence.
- Chapter 9 models the potential impact of improved TBI and SCI management strategies on the economic cost and burden of disease.

2. BACKGROUND TO SCI AND TBI

This chapter defines traumatic brain injury (TBI) and spinal cord injury (SCI) and describes severity classifications, cause of injury, morbidity, mortality and healthcare utilisation for these conditions. It also estimates the incidence for TBI/SCI in Australia and Victoria for the year 2008.

2.1 DEFINITIONS AND DIAGNOSIS

TBI

'Traumatic Brain Injury' (TBI) refers to brain injury acquired through a traumatic event, such as a traffic accident or a blow to the head (AIHW, 2008)[5]. There are varying severities of TBI which are commonly defined as mild, moderate and severe. These categories are most commonly assigned based on patient scores.

- **Glasgow Coma Scale (GCS) scores**. The GCS score measures a person's ability to open their eyes and motor and verbal function. A lower GCS score indicates a greater loss of consciousness which is typically associated with a greater severity of brain injury.
- **Duration of Post-traumatic amnesia (PTA).** PTA is utilised to indicate the likely deficit of cognitive and functional ability after TBI. It is defined as the period of time in which the brain is unable to retain continuous day-to-day memory (Khan et al, 2003).

TABLE 2-1: DEFINITIONS FOR CLASSIFYING TBI SEVERITY

	Glasgow Coma Scale scores	Duration of Post-traumatic amnesia	Inclusion within this analysis
Mild	12-15	<24 hours	Excluded
Moderate	9-11	1-7 days	Included
Severe	3-8	1-4 (weeks)	Included

Source: Khan et al (2003). Note: The GCS cut-off points vary across the literature. For the purposes of this analysis the more common classifications in this table are utilised.

> Moderate and severe TBI were included within this analysis. Mild TBI was excluded from this analysis.

SCI

'Spinal cord injury' (SCI) refers to the occurrence of an acute, traumatic lesion of neural elements in the spinal canal resulting in temporary or permanent sensory deficit, motor deficit or bladder/bowel dysfunction (AIHW, 2007). The severity of SCI is classified according to the last spinal cord segment where movement and feeling are normal as summarised in Table 2-2.

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[5] TBI is a subset of 'acquired' brain injury (ABI). For purposes of this report we assume data relating to ABI is transferable to TBI.

TABLE 2-2: DEFINITIONS FOR CLASSIFYING SCI SEVERITY

Last spinal cord segment injured	SCI classification	Associated morbidity
Cervical (spinal cord segments C1 to T1)	Quadriplegia[6]	Reduction or loss of motor and/or sensory function in the arms as well as in the trunk, legs, and pelvic organs.
Thoracic, lumbar or sacral (below the T1 cord segment)	Paraplegia	Reduction or loss of motor and/or sensory function in the trunk, legs, and pelvic organs.

Source: QSCIS (2001), AIHW (2008).

SCI can be due to traumatic or non-traumatic causes. Approximately 20% of SCI is due to non-traumatic (medical) causes such as ischaemia, cancer, spinal abscesses and spinal canal stenosis (Cripps, 2008). Only SCI due to traumatic causes was included in this analysis.

An 'incomplete' injury is one in which there is some movement or feeling below the level of the SCI. This implies that the damage in the spinal cord does not involve the whole spinal cord and that some messages are getting past the area of damage. In contrast, a 'complete' injury is one in which there is no movement below the level of the SCI (AIHW, 2008). This analysis does not separate complete from incomplete SCI.

> Paraplegia and quadriplegia due to 'traumatic' causes were included within this analysis.

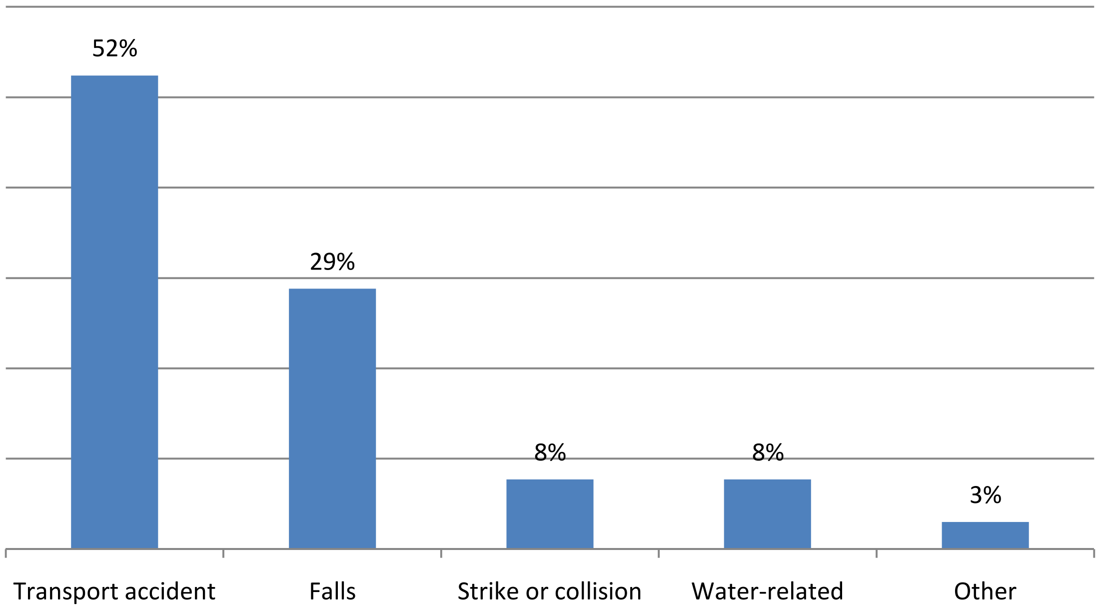
2.2 CAUSE OF INJURY

TBI

The leading causes of TBI in both Australia and Victoria are transport accidents, falls, collision with objects and water related accidents (Figure 2.1, Figure 2.2).

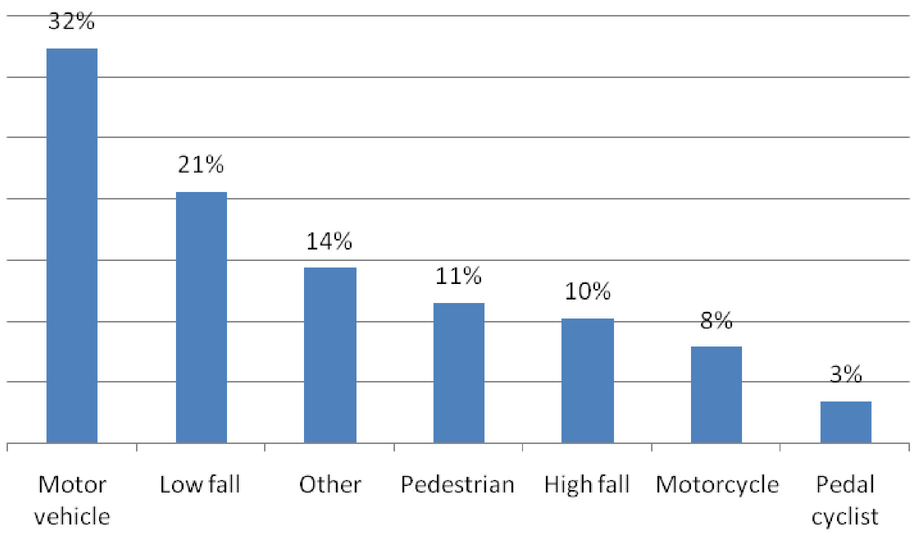
[6] Often referred to as 'tetraplegia'. For purposes of this report we assume data relating to tetraplegia is transferable to quadriplegia.

FIGURE 2.1: MECHANISM OF INJURY OF TBI IN AUSTRALIA, 2006-07



Source: AIHW (2009).

FIGURE 2.2: MECHANISM OF INJURY OF TBI IN VICTORIAN MAJOR TRAUMA CASES, 2007-08

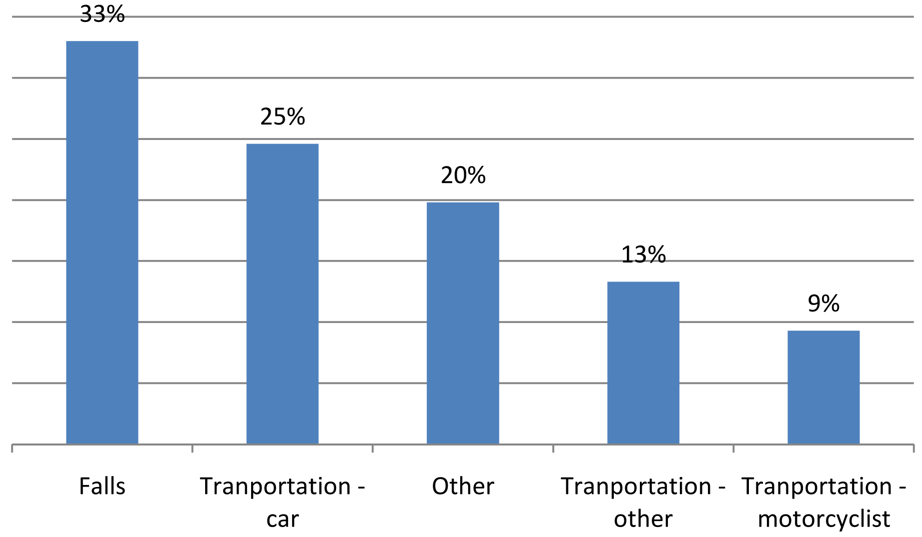


Source: VSTR (2009).

SCI

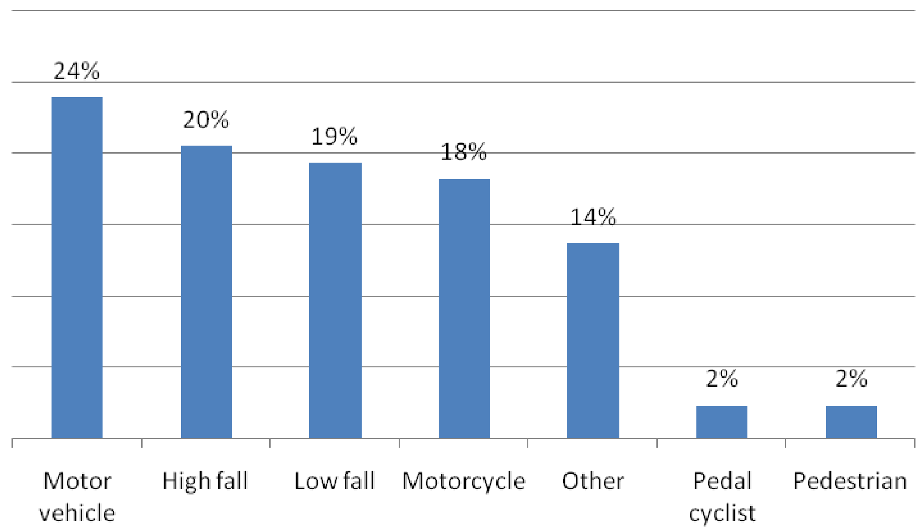
In an analysis of incident SCI cases admitted to hospital in Australia over the six year period July 1999 – June 2005, Henley (2009) found that 47% of cases were due to some form of transport accident. The next most common cause (33% of all incident cases) was falls – including tripping on the same level, falling from buildings and jumping into water (Figure 2.3). The mechanism of injury for Victorian cases was similar (Figure 2.4).

FIGURE 2.3: MECHANISM OF INJURY OF TRAUMATIC SCI, AUSTRALIA, 1999-2000 TO 2004-05



Source: Henley (2009).

FIGURE 2.4: MECHANISM OF INJURY OF SCI IN VICTORIAN MAJOR TRAUMA CASES, 2007-08



Source: VSTR (2009).

2.3 MORBIDITY

TBI

TBI can cause long-term physical disability and complex neuro-behavioural effects which disrupt quality of life, as summarised below.

- **Neurological impairment** - Motor function impairment affecting coordination, balance, walking, hand function and speech. TBI patients may also experience sensory loss, sleep disturbance, sexual dysfunction and medical complications (spasticity, post-traumatic epilepsy, hydrocephalus, heterotopic ossification).

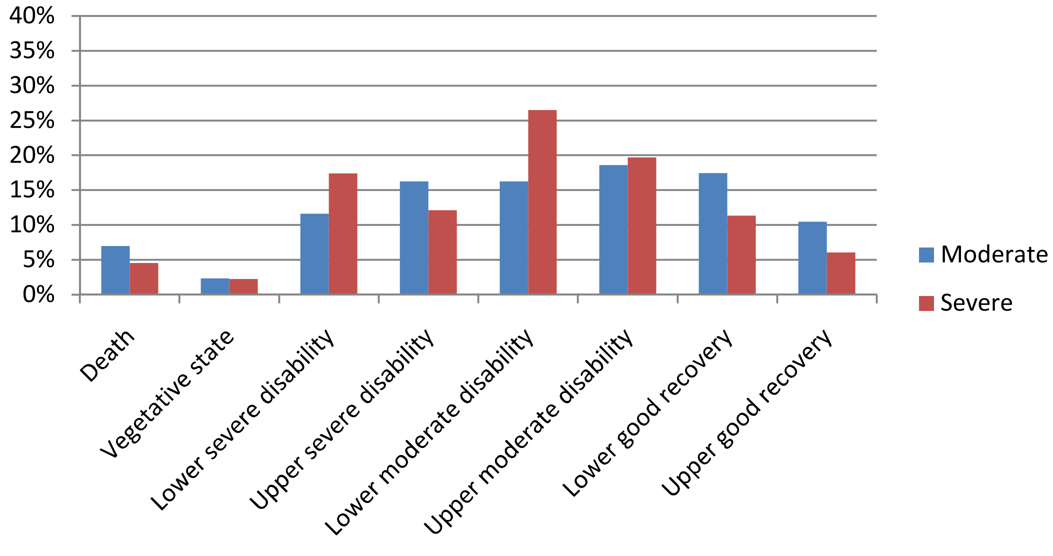
- **Cognitive impairment** – Memory impairment affecting learning, concentration, speed, flexibility of thought processing and problem solving skills. Problems with planning, language and safety awareness may also become evident.

- **Personality and behavioural changes** – Social and coping skills and self-esteem can become impaired. Emotional control, frustration tolerance and anger management may alter. A person may also experience reduced insight, disinhibition, impulsivity, apathy, amotivational states and psychiatric disorders such as anxiety, depression, post-traumatic stress disorder and psychosis.

- **Common lifestyle consequences** – These include unemployment and financial hardship, inadequate academic achievement, lack of transportation alternatives, inadequate recreational opportunities, difficulty in maintaining interpersonal relationships and loss of independence (Khan et al, 2003).

The Victorian State Trauma Registry (VSTR) routinely follows up all adults six months after injury to ascertain their functional and return to work or study status. Six-month Glasgow Outcome Scale – Extended (GOS-E)[7] scores are collected. GOS-E is a measure of disability. For all TBI cases followed up in 2007-08 the most frequent GOS-E scores were 'upper moderate disability' and 'lower moderate disability' for moderate and severe TBI respectively (Figure 2.5).

FIGURE 2.5: GOS-E SCORES AT SIX MONTHS FOR VICTORIAN TBI CASES, 2007-08



Source: VSTR (2009).

SCI

SCI can cause long-term physical disability and complex complications which disrupt quality of life, as summarised below.

- **Limitations in self-care ability and mobility**. A significant proportion of people with SCI have problems with mobility. A study of patients with chronic SCI who had been rehabilitated after injury found that 60% were wheelchair dependent (Post et al, 1998). Many need home modifications and specialised equipment to improve mobility.

[7] Additional information on the Glasgow Outcome Scale available at http://www.tbims.org/combi/gose/index.html

- **Problems in social functioning** Equipment, transportation and finance are factors that affect social functioning. Johnson et al (1998) found that at least 25% of SCI survivors experienced financial limitation five years post injury; approximately 20% experienced inadequate access to transport and just over 10% did not have durable medical equipment over the same period. Post et al (1998) also found levels of social functioning have an impact on life satisfaction for people with SCI.
- **Psychological complications**. Depression may occur and life satisfaction may be adversely effected (Post et al, 1998).
- **Medical complications.** The most common complications of SCI include urinary tract infections, bacterial infections and pressure ulcers. Other medical complications include bladder and bowel dysfunction, circulation problems, inability to control temperature, autonomic dysreflexia, respiration difficulties, sexual dysfunction, spasms, contracture and pain (musculoskeletal and neuropathic) (QSCIS, 2001). Approximately 70% of patients admitted to a hospital with a spinal unit had at least one of the complications listed in Table 2-3.
- **Sleep issues**. Obstructive sleep apnoea (OSA) has also been linked to respiratory problems which occur as a result of SCI. The prevalence of OSA in people with SCI is estimated at 9%-45% of cases (Burns et al, 2000).

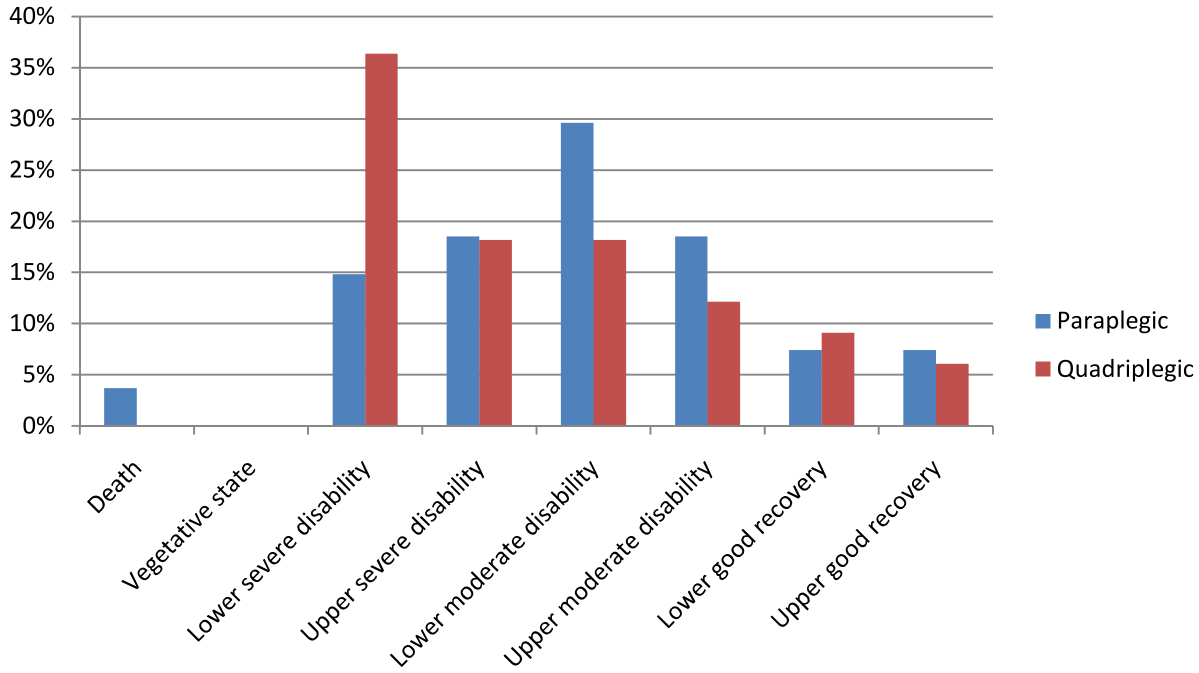
TABLE 2-3: COMPLICATIONS REPORTED BY HOSPITALS WITH A SPINAL UNIT FOR SCI READMISSION SEPARATIONS IN AUSTRALIA (1999-00 TO 2004-05)

Complication	Per cent of cases*
Urinary tract infection	24.3
Other bacterial infection	23.7
Pressure ulcer	19.3
Disorders of the bladder	17.1
Streptococcus/Staphylococcus infection	13.8
Autonomic dysreflexia	7.1
Urolithiasis	6.1
Hypertension	6.1
Spinal cord disease	4.8
Pneumonia	3.7
Cellulitis	3.6
Hypotension	3.2
Renal failure	3.1
Spasticity	3.0
Sepsis	3.0
Dorsalgia	2.7
Atelectasis	1.3
Bladder cancer	0.9
Osteoporosis	0.7
Deep vein thrombosis	0.5
Pulmonary embolism	0.4

Source: Henley (2009). * Sorted from highest to lowest.

For all cases followed up by VSTR in 2007-08 the most frequent GOS-E scores were ‘lower moderate disability’ and ‘lower severe disability’ for paraplegia and quadriplegia respectively (Figure 2.6).

FIGURE 2.6: GOS-E SCORES AT SIX MONTHS FOR VICTORIAN SCI CASES, 2007-08



Source: VSTR (2009).

2.4 UTILISATION OF HEALTH SERVICES

TBI

Treatment for people with TBI typically includes the following components.

- **Inpatient management** focuses on issues such as resuscitation, critical care management and surgery for the most serious cases, post-traumatic amnesia monitoring and imaging to ascertain TBI severity, as well as pain and pharmacological management.
- **Rehabilitation** for TBI is patient-specific. Depending on the type of cognitive disability experienced, it can include re-training in community living skills, domestic and household duties, communication (reading, writing, using the telephone), money management, time management, driving and public transport and social skills. It can also include cognitive and behavioural therapies and provision of assistive technology (Khan et al, 2003).
- **Behavioural management** may be necessary to increase independence and reduce maladaptive social behaviour (Khan et al, 2003).
- **Drug therapy** is also useful for mood disorders, such as depression and anxiety. Depression is common following TBI, with a reported prevalence of 10%–60%. Mood stabilisers can be used to help control anger sometimes exhibited by those with executive dysfunction (Khan et al, 2003).

During 2007, more than 16,000 cases of TBI were admitted to hospitals in Australia (AIHW, 2008). The average length of stay for all TBI cases was 6.1 days in acute care, 64.2 days in rehabilitation care and 84.1 days in other care (Helps et al, 2009).

TABLE 2-4: TBI CASES, BED-DAYS AND ALOS BY TYPE OF EPISODE OF CARE, BY SEX, AUSTRALIA, 2004-05

Type of episode of care		Males	Females	Persons
Acute care	Cases	14,863	6,741	21,604
	Bed days	89,172	42,389	131,561
	ALOS	6.0	6.3	6.1
Rehabilitation care	Cases	654	261	915
	Bed days	41,310	17,452	58,762
	ALOS	63.2	66.9	64.2
Other care	Cases	94	97	191
	Bed days	3,904	12,151	16,055
	ALOS	41.5	125.3	84.1
All types of care	Cases	15,611	7,099	22,710
	Bed days	134,386	71,992	206,378
	ALOS	8.6	10.1	9.1

Source: Helps et al (2009).

In addition to health care services, patients with TBI frequently receive disability support services. The most frequently received services for patients in Victoria are case management, individual therapy support and learning and life skills development (DHS, 2009).

TABLE 2-5: DISABILITY SERVICES RECEIVED BY VICTORIANS WITH AN ABI, 2008

Service received	Total	% of all cases receiving service
Case management, local coordination and development	1,231	39%
Therapy support for individuals	1,025	33%
Learning and life skills development	535	17%
Flexible respite	320	10%
In-home accommodation support	248	8%
Behaviour/specialist intervention	210	7%
Group home (<7 people)	161	5%
Centre-based respite/respite homes	112	4%
Other respite	64	2%
Recreation/holiday programs	21	1%
Own home respite	43	1%
Host family respite/peer support respite	19	1%
Attendant care/personal care	34	1%
Other accommodation support	1	0%
Hostels - generally not 24 hour care	10	0%

Source: DHS (2009).

SCI

Treatment for people with SCI typically includes the following components.

- **Acute treatment.** Treatment can be given to reduce the severity of SCI close to the time of trauma. High dose steroids are given in an attempt to reduce the severity of the injury in the spinal cord and therefore increase the chance of recovery. For vertebral fracture or dislocation, surgery may be required. During recovery patients may need intravenous drips for fluid, care to prevent pressure sores, physiotherapy to prevent contracture, treatment to prevent blood clots and respiratory problems and care of the paralysed bladder/bowel (QSCIS, 2001). Medical procedures for incident SCI separations are summarised in Table 2-6.

TABLE 2-6: SCI SEPARATIONS BY TYPE OF MEDICAL PROCEDURE AND TYPE OF HOSPITAL, AUSTRALIA, 1999-00 TO 2004-05

Hospital procedures	Hospitals with spinal unit	Hospitals without spinal unit
	% of all separations	
Generalised allied health intervention		
Physiotherapy	95.4	88.9
Occupational therapy	72.7	53.6
Social work	69.5	45.2
Dietetics	38.1	23.8
Other	60.5	40.5
Spinal procedures		
Computerised tomography of spine	48.1	67.1
Magnetic resonance imaging of spine	59.0	42.9
Repair of spine	42.9	17.0
Incision of spinal canal and spinal cord structures	16.7	12.8
Reduction of spine	19.6	9.6
Excision of spinal canal and spinal cord structures	8.0	7.5
Excision of spine	10.6	4.0
Application, insertion or removal of spine	6.4	3.6
Application, insertion or removal of spinal cord and spinal cord structures	3.0	3.1
Repair of spinal canal and spinal cord structures	0.9	1.7
Other procedures on spinal canal and spinal cord structures	0.7	1.1
Other procedures on spine	0.9	1.1
Continuous ventilatory support	**15.2**	**8.6**
Airway management	**5.6**	**2.1**
Procedure involving bladder	**11.3**	**2.8**
Other procedures	**1.6**	**4.8**

Source: Henley (2009).

- **Rehabilitation**. It is rare for complete recovery after SCI and, because of the number of possible subsequent medical complications, continued medical treatment and rehabilitative care is needed. For example, physiotherapists are required to advise on avoiding bed/pressure sores, particularly for those in wheelchairs or using supportive equipment. Rehabilitation methods to improve mobility are also undertaken by physical therapists.

Between 1999-00 and 2004-05, more than 16,000 cases of SCI were admitted to hospitals in Australia. The average length of stay for all SCI cases admitted to hospitals with spinal units was 26.0 days in acute care, 59.8 days in rehabilitation care and 103.0 days in other care (Henley, 2009).

TABLE 2-7: SCI HOSPITALISATIONS BY TYPE OF HOSPITAL AND TYPE OF CARE, AUSTRALIA, 1999-00 TO 2004-05

Type of episode of care	Hospitals with spinal unit			Hospitals without spinal unit			ALOS ratio
	Count	% all sep'ns	ALOS	Count	% all sep'ns	ALOS	
Acute care	6,813	77.3	26.0	9,654	87.0	9.0	2.9
Rehabilitation care	1,971	22.3	59.8	1,173	10.6	29.0	2.1
Palliative care	..	..	66.0	21	0.2	16.6	4.0
Other	34	0.4	103.0	245	2.0	31.2	3.3
Total	**8,819**	**100.0**	**33.8**	**11,093**	**100.0**	**11.6**	**2.9**

Source: Henley (2009).

2.5 MORTALITY

TBI

Synthesising the global literature regarding mortality risk after TBI is challenging due to heterogeneous study populations (for example variable injury severity and mode of injury) and study methodologies (for example, time period for review and inclusion/exclusion of acute mortality). Therefore, research findings show significant variation. However, almost all studies report that mortality rates in adult populations following TBI are higher than those expected in a non-injured, matched population sample. A selection of recent studies is summarised in Table A1, Appendix A.

Baguley et al (2008) synthesised previous literature regarding the risk of mortality after TBI as follows.

- **Standardised mortality rates (SMR):** SMR following TBI increase by a factor between 1.1–4.0 relative to age and sex-matched population samples.
- **Life expectancy:** is reduced by 3–9 years for moderate-severe TBI.
- **Disability severity:** mortality rates increase with TBI severity (e.g. mortality rate for severe TBI are 40-fold higher than mild TBI).
- **Timeframes:** The greatest proportion of deaths attributable to TBI occur in the early years post discharge. Specifically, around 30–35% of patients admitted with moderate-severe TBI die within the first 30 days following the injury.
- **Cause:** the most common causes of death in TBI patients include pneumonia, stroke and haemorrhage.

This analysis reviews and extrapolates results from three 'recent' studies/datasets (to capture mortality trends under contemporary healthcare services) based on 'Australian' patients with TBI (to ensure transferability of results to the Australian population).

- Myburgh et al (2008): collected 12-month mortality data for Australian and New Zealand patients with mild, moderate and severe TBI.
- Baguley et al (2008): collected 10-year mortality data for Australians patients with severe TBI.

- VSTR (2009); collected 6 month mortality data for TBI patients on the Victorian trauma registry in 2007-08 (Table 2-9).

Myburgh et al (2008) reported the 12-month mortality rate for patients with severe TBI as 35.1%. This mortality rate is consistent with the 10-year mortality for severe TBI reported by Baguley et al (2008) (36%) and similar to the six-month mortality reported by VSTR for severe TBI (39%). Conservatively, the lowest mortality rate (35.1%) was adopted for patients with severe TBI for this analysis. Given that most of the mortality attributable to TBI occurs in the first 12 months post injury, the mortality rate was applied to the year after injury only. Patients surviving year 1 reverted to the mortality risk for the general population (Table 2-9).

Upon request, the lead author of the study by Myburgh et al (2008) – John Myburgh, currently Professor of Critical Care Medicine, and University of New South Wales – kindly provided previously unpublished mortality rates for the combined mild/moderate group equivalent to 9.1%. However, data were not available for the moderate TBI group only. Therefore, for moderate TBI the six-month mortality rate (22.6%) from the VSTR was adopted.

TABLE 2-8: SIX-MONTH MORTALITY RATES OBSERVED FOR VICTORIAN TBI CASES IN 2007-08

	Moderate TBI	Severe TBI
Time period 1: In hospital		
N	141	248
Numbers of deaths	22	86
Mortality rate	16%	35%
Time period 2: Surviving at discharge to 6-months post injury		
N	86	132
Numbers of deaths	6	6
Mortality rate	7%	5%
Combined mortality (time period 1 + 2)	**22.6%**	**39.2%**

Source: VSTR (2009).

TABLE 2-9: YEAR 1 MORTALITY RATES ADOPTED FOR ANALYSIS

Initial GCS	TBI severity category	1 year
<8	Severe	35.1%
9 - 12	Moderate	22.6%

Source: Myburgh et al (2008), VSTR (2009), Baguley et al (2008).

Differences in mortality risk across age groups and gender have been observed (Table 2-10) but not clearly quantified, so the higher mortality risk from Table 2-9 was applied equally across all age groups and both genders. Consistency across studies provides some confidence in the mortality rates adopted.

TABLE 2-10: MORTALITY AND TBI DEMOGRAPHIC TRENDS

Gender	Mortality rates for males were marginally higher than females (Baguley, 2008).
Age	The deceased group were older at the time of injury (Baguley, 2008, Flaada et al, 2007).

> The mortality rates in the year of injury were assumed to be 22.6% for moderate TBI and 35.1% for severe TBI. General population mortality rates were applied to cases surviving after year 1.

SCI

There are a number of international studies which analyse SCI mortality. However it is difficult to create a comparable overview of the evidence for the same reasons outlined for TBI. Overall, there is consensus that populations with SCI have higher mortality when compared with the general population. A summary of the global evidence is summarised as Table A2 in Appendix A.

This analysis reviews the results from two 'recent' studies/datasets (to capture mortality trends under contemporary healthcare services) based on 'Australian' patients with SCI (to ensure transferability of results to the Australian population).

- Yeo et al (1998) collected acute (one month) and 18 month mortality for 1,453 SCI patients from the spinal unit of Royal North Shore Hospital (Sydney) patients over a 40 year period.
- VSTR (2009) collected six month mortality for SCI patients on the Victorian trauma registry in 2007-08.

Yeo et al (1998) reported:

- **Life expectancy** - Projected mean life expectancy of people with SCI compared to that of the whole population was estimated to approach 70% of normal for individuals with complete quadriplegia and 84% of normal for complete paraplegia.
- **Timeframes:** Mortality within the first 18 months post injury comprised almost all mortality following SCI.
- **Disability severity:** mortality rates increase with SCI severity (e.g. the average mortality rate for quadriplegia is over double the comparable figure for paraplegia).

Mortality rates reported by Yeo (1998) and VSTR (2009) are summarised in Table 2-11. The results from Yeo are adopted for this analysis because they were taken from a large sample of SCI patients.

TABLE 2-11: YEAR 1 MORTALITY RATES REPORTED FOR SCI (%)

Injury level	Yeo et al (1998)			VSTR (2009)		
	Acute (1st month)	Long term (2-18 months)	Overall	Acute (in hospital)	Short term (up to 6 months from discharge)	Overall
Paraplegia (thoracic and lumbar)	5.4	1.0	6.4	5.6	3.7	9.3
Quadriplegia (cervical)	12.1	1.6	13.7	28.8	0	28.8

Source: Yeo et al (1998) and VSTR (2009).

Given that most of the mortality attributable to SCI occurs in the first 12 months post injury, the mortality rate was applied to the year after injury only. Patients surviving one year reverted to the mortality risk for the general population. The same method (addition to background mortality rate) and limitations (uncertainty regarding attribution to SCI) as described under TBI apply.

The mortality rates in the year of injury were assumed to be 6.4% for paraplegia and 13.7% for quadriplegia. General population mortality rates were applied after the first year.

2.6 ESTIMATED INCIDENCE - AUSTRALIA

TBI

Incidence data available. The National Injury Surveillance Unit (NISU) at Flinders University is the AIHW collaborating agency tasked with surveillance at the national level in the area of injury. NISU have not previously published incidence data for TBI due to a range of data limitations and methodological issues[8]. However, based on data retrieved from the AIHW National Hospital Morbidity Database (NHMD), NISU have published data on the number of hospital separations due to TBI in 2004-05 (Helps et al, 2008). This study reported 22,710 TBI separations (TABLE B1) based on the following inclusion criteria:

- **definition of TBI**: all ICD-10 S06 codes (refer to TABLE B2);
- **cause of injury**: cases restricted to ‘traumatic’ causes;
- **diagnosis**: cases included TBI as principal or additional diagnosis; and
- **time period**: 2004-05.

After a series of adjustments to the number of separations reported by Helps et al (2008) summarised in Appendix B, the number of new cases of moderate/severe TBI combined in 2008 was estimated to be 5,480. However, this incidence rate (26 moderate/severe cases per 100,000 persons) appears high when compared to the estimated incidence rates for moderate and severe TBI in the state of Victoria (7.0 and 4.7 cases per 100,000 respectively, based on VSTR data). Therefore, conservatively and to ensure consistency in methods for estimating incidence rates for the Australian and Victoria analysis, the Victoria incidence rates were applied to the Australian population in 2008 to estimate national incidence.

[8] Source: personal consultation with NISU, 16/4/9

Separations data for the ICD-10 codes relating to TBI (all S06 as reported by Helps et al, 2008) for the year 2008 were retrieved from the AIHW NHMD disaggregated by gender and age. This age and gender distribution was applied to the estimated number of incident cases of moderate and severe TBI for Australia.

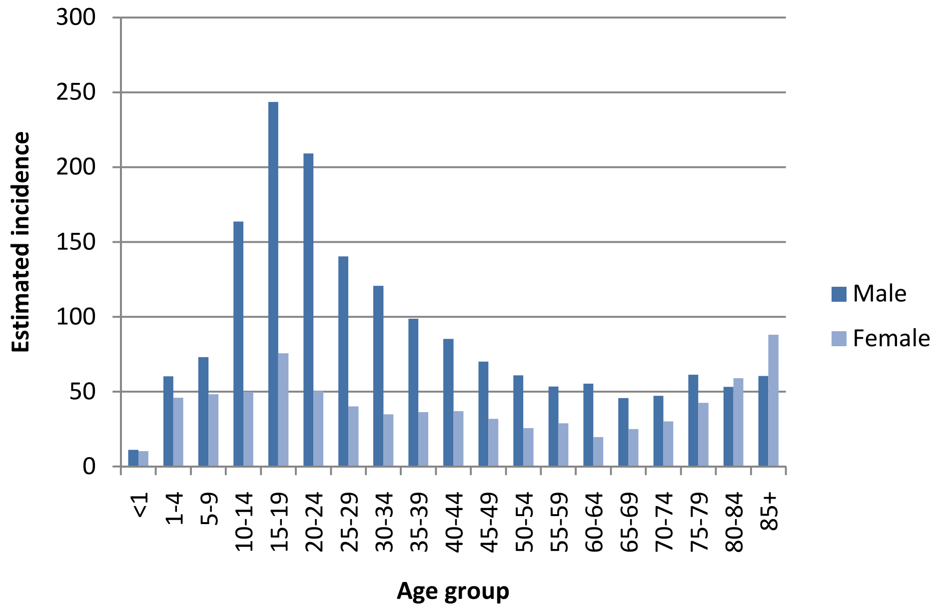
Incidence estimates. The number of incident cases for Australia in 2008 was estimated to be 1,493 for moderate TBI and 1,000 for severe TBI (Table 2-12). This is equivalent to incidence rates of 7.0 and 4.7 cases per 100,000 persons for moderate and severe TBI respectively. The number of cases was estimated to be over double for males relative to females, and the highest SCI case count was estimated to be for young adults aged 15-25. The age and gender distribution for moderate and severe (combined) TBI is demonstrated in Figure 2.7.

TABLE 2-12: INCIDENT CASES OF TBI BY SEVERITY AND GENDER, AUSTRALIA, 2008

Moderate TBI			Severe TBI			Combined total
Male	Female	Total	Male	Female	Total	
1,026	467	1,493	688	313	1,000	2,493

Source: Estimate based on data reported by VSTR (2009), Tate et al (1998) and AIHW NHMD (2009).

FIGURE 2.7: INCIDENT CASES OF TBI BY AGE, GENDER AND SEVERITY, AUSTRALIA, 2008



Source: Estimate based on data reported by VSTR (2009), Tate et al (1998) and AIHW NHMD (2009).

> For the year 2008 in Australia, there were an estimated 1,493 new cases of moderate TBI and 1,000 new cases of severe TBI.

SCI

The NISU published data on the number of new cases of persisting SCI in 2006-07 based on cases registered by the Australian Spinal Cord Injury Register (ASCIR) (Cripps 2008). The ASCIR captures all adult cases admitted to the six Australian hospitals with specialist SCI units. Within this report, NISU reported the number of incident cases of SCI due to traumatic causes as 272 in 2006-07. The gender ratio was reported to be 83% male and 17% female and the severity split was reported as 49.8% paraplegia and 50.2% quadriplegia.

The incidence of paraplegia and quadriplegia in Australia in 2008 was estimated based on the incident number of cases reported by Cripps for 2006-07 and the following adjustments:

- **Applied an age/gender distribution**. Separations data for the ICD-10 codes relating to SCI (codes as reported by all ICD-10 SCI codes (consistent codes utilised to retrieve national SCI separations data by Henley (2009), the year 2006-07 were retrieved from the AIHW NHMD disaggregated by gender and age. This age and gender distribution was applied to the estimated number of incident cases of paraplegia and quadriplegia.
- **Increased incidence consistent with population growth between 2006 to 2008**. Age and gender specific population incidence rates were estimated for the year 2006. Age and gender specific incidence rates were then applied to the 2008 Australian population. Population data were sourced from the Access Economics demographic model which is based on ABS data and projections.

The number of incident cases for Australia in 2008 was estimated to be 137 for paraplegia and 136 for quadriplegia (Table 2-13). This is equivalent to incidence rates of 0.6 and 0.6 cases per 100,000 persons for paraplegia and quadriplegia respectively. SCI was approximately five-fold more common in males relative to females, and similar to TBI, cases were most common in young adults aged 15-25. The age and gender distribution for paraplegia and quadriplegia (combined) is illustrated in Figure 2.8.

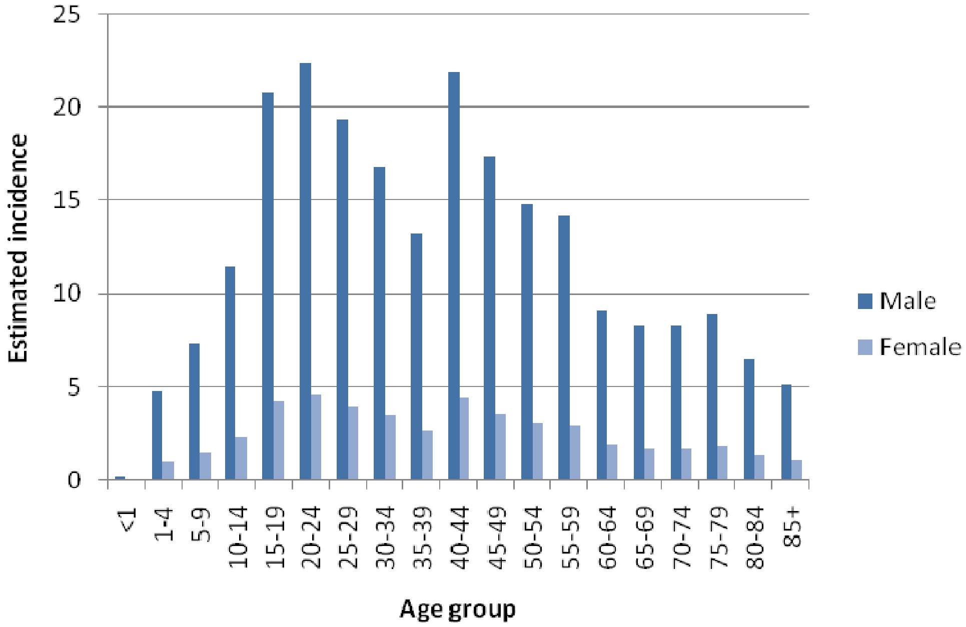
This incidence of SCI estimated for this analysis in 2008 (278 SCI cases) is likely to be conservative. In a recent NISU publication reporting SCI separations between 1 July 1999 and 30 June 2005 based on data retrieved from the AIHW NHMD, the number of SCI-related separations admitted to hospitals with and without SCI units were reported as 3,806 and 5,280 (ratio of 1:1.39) respectively. Therefore it is likely that some SCI cases are not admitted to SCI specialist hospitals and not captured in the ASCIR. The economic costs based on SCI cases admitted to all hospitals is included within a sensitivity analysis and specific methods for the estimation of incidence are described in Appendix B.

TABLE 2-13: INCIDENT CASES OF SCI BY SEVERITY AND GENDER, AUSTRALIA, 2008

Paraplegia			Quadriplegia			Combined total
Male	Female	Total	Male	Female	Total	
114	23	137	113	23	136	274

Source: Cripps (2008), AIHW NHMD (2008)

FIGURE 2.8: INCIDENT CASES OF SCI BY AGE, GENDER AND SEVERITY, AUSTRALIA, 2008



Source: Cripps (2008), AIHW NHMD (2008).

For the year 2008 in Australia, there were an estimated 137 new cases of paraplegia and 136 new cases of quadriplegia.

2.7 ESTIMATED INCIDENCE - VICTORIA

TBI

Upon request, VSTR provided data on the number of incident cases of TBI meeting registry entry criteria for 2007-08. The data request included the following parameters:

- **definitions**: all ICD-10 S06 codes (consistent with codes utilised to retrieve national TBI separations data by Helps et al, 2008);
- **inclusions**: cases included where TBI was principal or additional diagnosis (consistent with the approach used to retrieve national TBI separations data by Helps et al (2008);
- **time period**: 2007-08; and
- **severity**: classified using the Glasgow Coma Scale as mild, moderate and severe (consistent with scores described in Section 2.1).

Incident cases reported by VSTR are unlikely to capture all TBI cases, particularly moderate TBI. This is because VSTR entry criteria include that cases must have been admitted to hospital and must have an Injury Severity Score (ISS) > 15. Many moderate cases of TBI are unlikely to meet these conditions[9]. Therefore, VSTR is perceived to be a reasonable source to estimate the number of new cases of severe, but not moderate TBI.

[9] Source: Personal consultation with VSTR, 15/04/09

Tate et al (1998) reported the severity breakdown for hospital treated TBI in NSW as mild = 62.2%, moderate = 20.3% and severe = 13.6% (remaining 3.9% of cases died). Therefore the ratio of moderate to severe TBI was 1.49:1.0. This ratio was adopted to estimate the number of severe TBI cases in Victoria (calculated as number of severe TBI cases x 1.49).

The number of new moderate TBI cases was estimated as 370 and the number of new severe TBI cases was reported by VSTR as 248 (Table 2-14). This is equivalent to incidence rates of 7.0 and 4.7 cases per 100,000 persons for moderate and severe TBI respectively. The age and gender distribution for moderate and severe TBI (combined) was similar to that from the Australian data and is indicated in Figure 2.9.

Incident cases reported by VSTR are unlikely to capture all state-wide cases (and are therefore likely conservative) due to the following reasons.

- A small proportion (8%) of hospitalised major trauma cases in Victoria in 2007-08 registered by the VSTR did not have ICD-10 codes documented. Any TBI cases in this group were excluded from reported incident cases[10].
- Deaths prior to arriving at hospital were excluded.

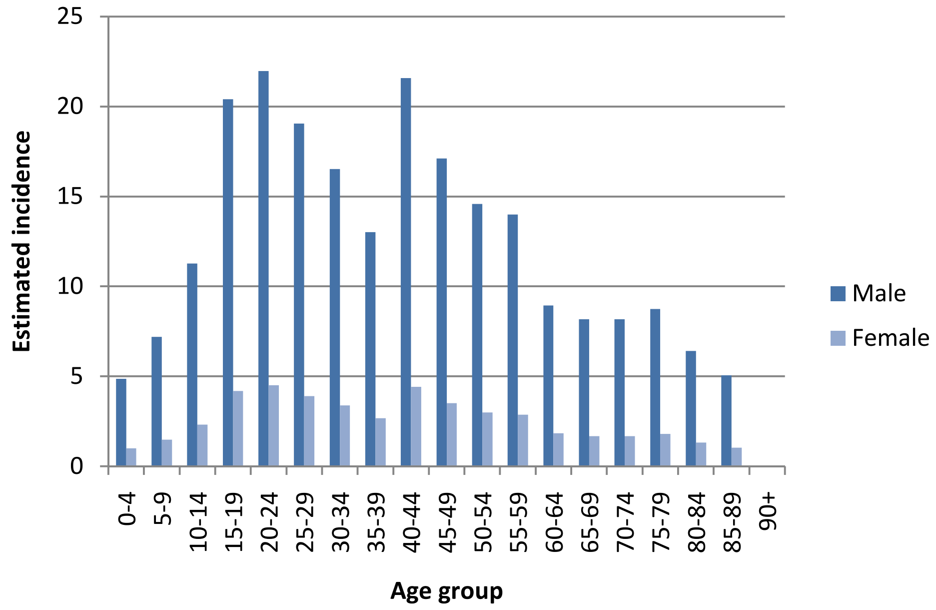
TABLE 2-14: INCIDENT CASES OF TBI BY SEVERITY AND GENDER, VICTORIA, 2008

Moderate TBI			Severe TBI			Combined total
Male	Female	Total	Male	Female	Total	
249	121	370	187	61	248	618

Source: VSTR (2009), Tate et al (1998).

[10] VSTR utilise AIS as primary coding system. However, at request kindly provided cases by ICD-10 codes to enable comparability with National data reported by NISU.

FIGURE 2.9: INCIDENT CASES OF TBI BY AGE, GENDER AND SEVERITY, VICTORIA 2008



Source: VSTR (2009). Note: The only adjustment required for modelling purposes was to convert age categories from 10 year to 5 year brackets. Frequencies for each 10 year bracket were applied evenly across the two composite five year groups. e.g. age 35-44 (incidence 54), divided into age groups 35-39 and 40-44 and incidence of 27 assigned to each. No cases assigned to age groups 0-10 and 85+.

For the year 2008 in Victoria, there were an estimated 370 new cases of moderate TBI and 248 new cases of severe TBI.

SCI

Upon request, VSTR provided data on the number of incident cases of SCI meeting registry entry criteria for 2007-08. The data request included the following parameters:

- **definitions**: all ICD-10 SCI codes (consistent codes utilised to retrieve national SCI separations data by Henley, 2009);
- **inclusions**: cases included where SCI was principal or additional diagnosis (consistent with approach utilised to retrieve national TBI separations data by Henley (2009); and
- **time period**: 2007-08.

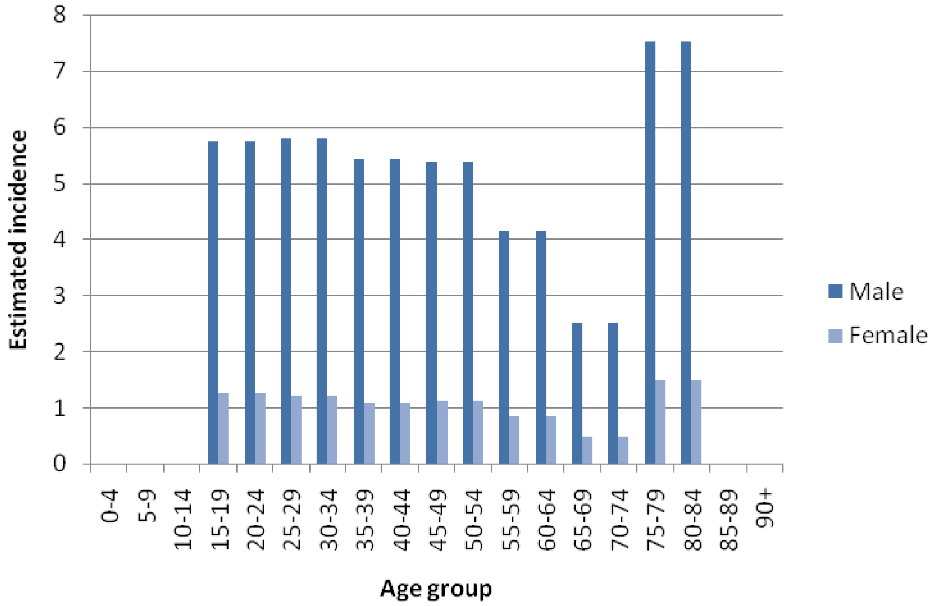
The number of incident cases was reported as 36 and 52 for paraplegia and quadriplegia respectively TBI (Table 2-15). The age and gender distribution for paraplegia and quadriplegia combined was similar to the Australian data and is illustrated in Figure 2.10.

TABLE 2-15: INCIDENT CASES OF SCI, BY SEVERITY AND GENDER, VICTORIA, 2008

Paraplegia			Quadriplegia			Combined total
Male	Female	Total	Male	Female	Total	
29	7	36	44	8	52	88

Source: VSTR (2009).

FIGURE 2.10: INCIDENT CASES OF SCI BY AGE, GENDER AND SEVERITY, VICTORIA, 2008



Source: VSTR 2009. Note: The only adjustment required for modelling purposes was to convert age categories from 10 year to 5 year brackets. Frequencies for each 10 year bracket were applied evenly across the two composite five year groups. e.g. age 35-44 (incidence 13), divided into age groups 35-39 and 40-44 and incidence of 6.5 assigned to each. No cases assigned to age groups 0-10 and 85+.

Incident cases reported by VSTR are likely to be conservative for the same reasons outlined under TBI.

For the year 2008 in Victoria, there were an estimated 36 new cases of paraplegia and 52 new cases of quadriplegia.

2.8 PREVALENCE

TBI

A literature review revealed no clear estimates of TBI prevalence. This was confirmed by NISU[11]. A project on injury in Australia is currently estimating the prevalence of TBI employing the global burden of disease method[12].

SCI

O'Connor (2005) estimated that the prevalence of SCI in 1997 was approximately 10,000 cases, and predicted that this would be 12,000 by 2021. Similarly, Cripps (2008) estimated SCI prevalence in 2006-07 to be 9,000. However, for reasons outlined in Section 2.6, these estimates may be conservative.

[11] Source: Personal communication with NISU, email17/4/09

[12] Additional information is available at: http://sites.google.com/site/gbdinjuryexpertgroup/Home

3. CROSS-CUTTING METHODOLOGICAL ISSUES

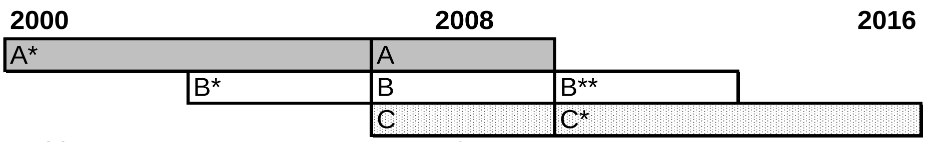
3.1 INCIDENCE AND PREVALENCE APPROACHES TO COST MEASUREMENT

Incidence approaches measure the number of new cases of a given condition (in this case TBI/SCI) in a base period (in this case calendar year 2008) and the costs associated with treating them, as well as other financial and non-financial costs (e.g, productivity losses, loss of quality of life) over the person's lifetime, due to the condition. The total costs represent the net present value (NPV) of current and future costs incurred due to new cases in the year in question.

In contrast, prevalence approaches measure the number of people with a given condition in a base period and the costs associated with treating them as well as other financial and non-financial costs (productivity losses, loss of quality of life) in that year, due to the condition. Prevalence approaches can be more suitable for chronic conditions and for a snapshot of total economy-wide costs that will be borne in a given year.

Figure 3.1 depicts the difference between an incidence approach, estimating the present value of the lifetime costs of new cases of TBI/SCI in 2008 (area C plus the present value of C* in Figure 3.1) and a prevalence approach (areas A+B+C in Figure 3.1). Consider person A, who experienced TBI/SCI in 2000 and continued to experience its impacts until death in 2008. This person would be included in a prevalence approach (but not in an incidence approach), although only the costs incurred in 2008 would be included (i.e. A but not A*, where A includes the present value of premature mortality costs if the death was premature). Person B developed TBI/SCI in 2004 and experiences its impacts through to 2011 (with costs of B+B*+B**); she also would be counted (but only costs of B) using a prevalence approach, but not using an incidence approach. Person C (shaded in grey dots) is newly diagnosed with TBI/SCI in 2008 and his costs in 2008 (C) would be included in a prevalence approach but not future costs (C*). In an incidence approach, only person C is included, with total costs being C plus the present value of C*.

FIGURE 3.1: PREVALENCE AND INCIDENCE APPROACHES TO COST MEASUREMENT



Incidence costs = C + present value of C*. Prevalence costs = A + B + C

> An incidence based costing approach was employed due to the availability of more robust incidence data and linkages with the associated cost effectiveness analysis.

3.2 NET PRESENT VALUE AND THE DISCOUNT RATE

Where future costs are ascribed to the year 2008 throughout the report the formula for calculating the NPV of those cost streams is provided below.

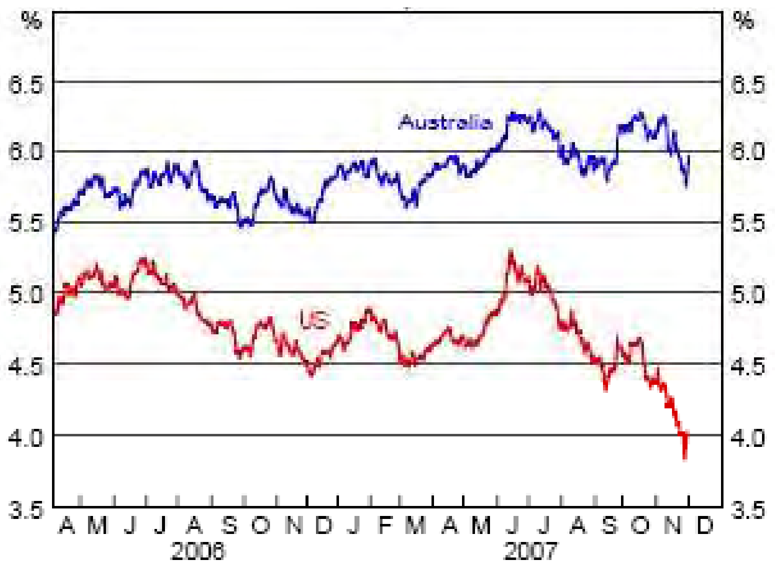
$$NPV = \Sigma C_i/(1+r)^{\wedge i} \text{ where } i=0,1,2\ldots n \qquad \text{where}$$

C_i = *cost in year i, n = years that costs are incurred and r = discount rate.*

Choosing an appropriate discount rate is a subject of some debate, as it varies depending on what type of future income or cost stream is being considered. The discount rate needs to appropriately take into account risks, inflation and positive time preference.

- **Risk and positive time preference**: The minimum option that one can adopt in discounting future expected healthy life streams and other costs is to set future values on the basis of a risk free assessment about the future ie. assume the future flows are similar to the certain flows attaching to a long-term Government bond. From recent history, the long-term nominal bond rate has averaged 5.8% per annum (Figure 3.2). If there were no positive time preference, people would be indifferent between having something now or a long way off in the future, which applies to all goods and services.

FIGURE 3.2: 10-YEAR GOVERNMENT BOND YIELDS (DAILY)



Source: Bloomberg, Reserve Bank of Australia.

- **Inflation**: The Reserve Bank has a clear mandate to pursue a monetary policy that delivers 2% to 3% inflation over the course of the economic cycle. This is a realistic longer run goal and an inflation rate in this range (2.8%) is used in arriving at the discount rate for healthy life below. It is important to allow for inflation in order to derive a real rather than nominal rate.

The Victorian Competition and Efficiency Commission (2007) recommended using a real discount rate of 3.5%, whereas the Office of Best Practice Regulation (Australian Government, 2007) recommended using a real rate of 7% in the base case. Sensitivity analysis will therefore be undertaken using a real discount rate of 7%.

> In discounting healthy life and other costs in this report, a real discount rate for Australia is thus used of (5.8 – 2.8 =) 3%. This represents the base case. The reference year for all costs was 2008.

3.3 LITERATURE SEARCH

Beyond what was readily available through these sources, literature searches for relevant medical journal articles were conducted through the PubMed database in late April to early May 2008. Terms that were searched include:

- TBI/SCI AND (incidence OR prevalence OR frequency);
- TBI/SCI AND risk factors;
- TBI/SCI AND (mortality OR life expectancy);
- TBI/SCI AND (utility OR disability weight OR quality of life); and
- TBI/SCI AND (employment OR productivity).

4. METHOD FOR ESTIMATING HEALTHCARE, LONG TERM CARE AND EQUIPMENT AND MODIFICATIONS COSTS

This chapter describes the data sources and methods for the calculation of the healthcare, long term care, and equipment and modifications costs, which are utilised in subsequent chapters. The methods are common to these three cost categories and the cost data are sourced from the TAC.

4.1 SOURCE FOR COST DATA (TAC)

Cost data were retrieved from the TAC including:

- detailed cost descriptions;
- conditions: moderate TBI[13], severe TBI (consistent with GCS classifications described in 2.1) and paraplegia and quadriplegia;
- age categories;
- date or year of injury/onset;
- gender; and
- pay years 2004-2008.

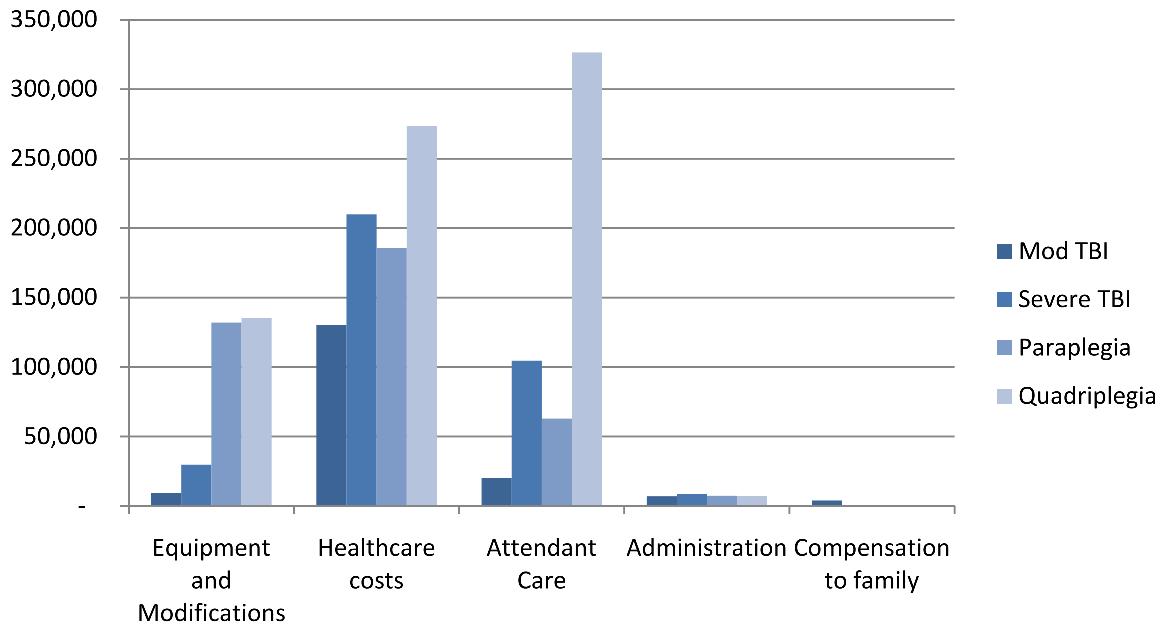
TAC cost data broadly included five categories:

1. healthcare costs (described in Chapter 5);
2. equipment and modifications costs (described in Chapter 6);
3. long term care costs (described in Chapter 6);
4. compensation to families for fatal accidents (conservatively excluded due to inability to separate deaths at the scene of the accident);
5. loss of earnings and medico-legal costs (excluded due to duplication with costs calculated using alternative cost sources and described in Chapter 6).

The cost categories (4) and (5) above, which are excluded from this analysis, represent a small proportion (<2%) of overall TAC costs. The key cost drivers of TAC claims for TBI/SCI patients were hospital costs (a component of healthcare) and long term care costs. These two categories constituted 52% of all TAC costs for TBI/SCI patients between 2004-2008 (Figure 4.1).

[13] For the moderate classification, TAC had some reservations regarding GCS data, specifically regarding the whether GCS were collected at the same time. Furthermore some cases did not have GCS data and were therefore for excluded from the analysis.

FIGURE 4.1: MEAN COST FOR SIX YEARS POST INJURY, BY COST CATEGORY AND CONDITION ($)



Source: TAC (2009).

Cost data was sourced from the Transport Accident Commission Victoria.

4.2 APPLICATION OF COST DATA

Calculation of mean per patient costs

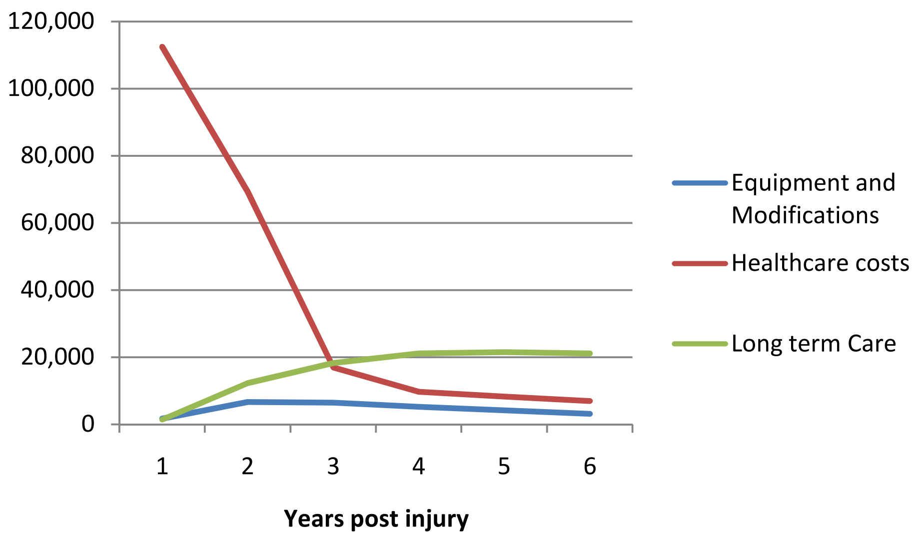
The TAC data were 'claims' data not patient data. Therefore the approach to estimating costs over time per patient was as follows.

- A category 'time since injury category' was developed based on the year of injury and the year of payment.
- Claims in the 'greater than six year post injury' category were ignored because the sample was small.
- The mean annual cost per patient (for each cost category and time post injury) was calculated by dividing the sum of claims by the number of 'eligible' patients (patients with TBI/SCI who were on TAC books). The number of 'eligible patients' was assumed to be equal to the sum of all patients in 'year 1' (year of injury) over the cost data period (a proxy for all new cases entering the TAC compensation eligibility system).

Costs applied over time

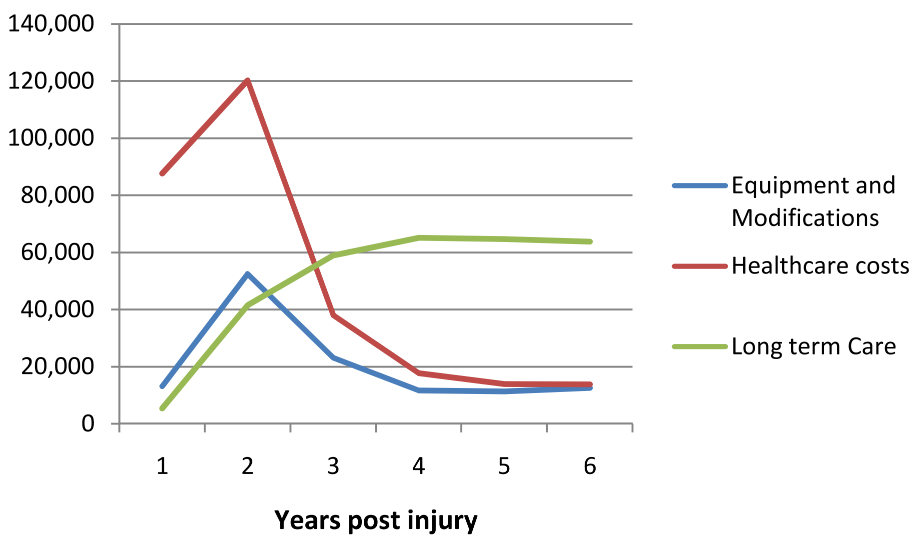
Cost trends over time (years post injury) were very pronounced. For example, for severe TBI and quadriplegia, mean TAC healthcare costs decreased over time in the first six years post injury (from $112,641 and $87,755 respectively in the first year to $7,024 and $14,122 by year 6). In contrast, long term care costs increased over the same time period and then stabilised (Figure 4.2, Figure 4.3). To capture these trends in the cost model, costs were calculated and applied based on years post injury from year 1-6.

FIGURE 4.2: MEAN ANNUAL COST OVER TIME BY COST TYPE, SEVERE TBI ($)



Source: TAC (2009).

FIGURE 4.3: MEAN ANNUAL COST OVER TIME BY COST TYPE, QUADRIPLEGIA ($)



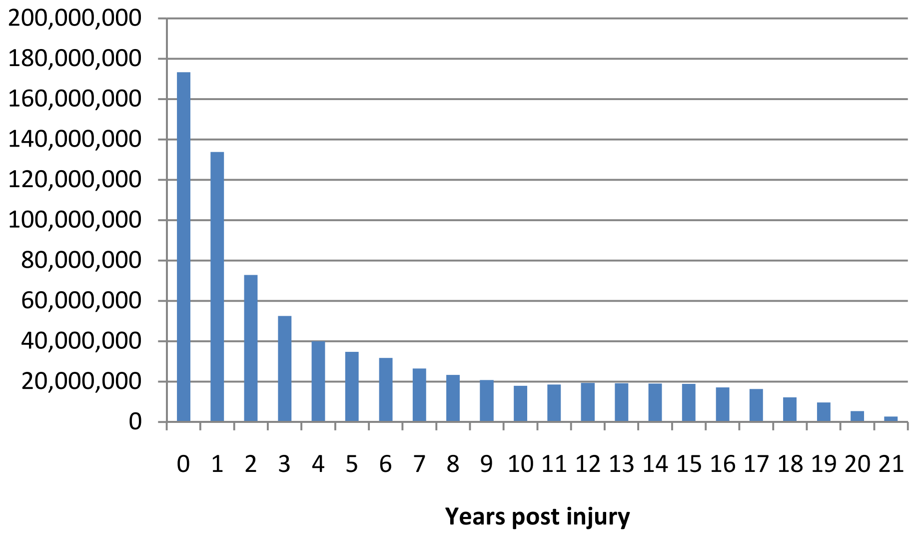
Source: TAC (2009).

After six years, the TAC cost data were much more difficult to interpret (primarily due to small samples (the dataset related to the previous five years 2004-2008). Therefore, for all years after year 6, constant costs were applied based on year 6 values and (year 4-6) cost trends as summarised in Table 4-1. Consistent with the TAC funding model these costs were applied for the remainder of the patient's lifetimes (Figure 4.4).

TABLE 4-1: APPROACH TO CALCULATE COSTS AFTER YEAR SIX POST INJURY

Cost category	Year 4-6 trend	Approach to calculate costs after year 6
Healthcare costs	Decreasing	50% of year 6 costs
Equipment and modifications costs	Decreasing	50% of year 6 costs
Long term care costs	Increasing	100% of year 6 costs

FIGURE 4.4: TOTAL COST OF CLAIMS (2004-2008) BY YEARS SINCE INJURY ($)



Source: TAC (2009).

All costs were inflated from their pay year to real prices in the reference year 2008 based on AIHW health inflators (AIHW, 2008). No significant demographic trends were observed and therefore costs were applied regardless of age and gender.

> Mean per patient costs were calculated based on years post injury for TBI/SCI.

4.3 TRANSFERABILITY ISSUES

The TAC data are a rich and large data source for patients with the target conditions of TBI and SCI. Therefore, these costs were utilised as the basis for the calculation of healthcare, equipment and modifications and long term carer costs. However, these costs are unlikely to be transferable to all Australian SCI and TBI patients. The following transferability issues were considered and are described in detail below:

- transferability to non-compensable patients (TAC patients are 'compensable');
- transferability across states (TAC patients are Victorian); and
- transferability to cases not caused by transport accidents (TAC patient injuries are caused by transport accidents).

Transferability to non-compensable patients

In Australia, the medical and rehabilitation expenses of individuals injured in transport accidents are typically financed by state government monopoly regulators. All Australian states and territories have compulsory third party (CTP) motor vehicle accident regulators. There are substantial differences between the transport accident schemes that operate in Australia. The minority are 'no fault' schemes in which compensation is provided irrespective of whether the injured individual was at-fault or not-at-fault (i.e, the Victoria, Tasmania, Northern Territory and partial 'no fault' in NSW). In these schemes benefits vary with treatment expenses generally provided and different systems for compensation for non-economic loss (permanent disability). Schemes such as those in Queensland and SA are fault-based, common law schemes. Since 1999, tort schemes such as these have also introduced a range of tort reforms, such as caps on general damages (i.e. payments for pain and suffering), which are designed to limit claims and insurance premium growth (Table 4-2).

TABLE 4-2: STRUCTURE OF AUSTRALIAN TRANSPORT ACCIDENT COMPENSATION SCHEMES

Exclusive no-fault	No-fault and common law	Exclusive common law
Northern Territory (residents)	Victoria	New South Wales (plus 'partial' no fault)
	Tasmania	ACT
		Queensland
		Western Australia
		South Australia
		Northern Territory (visitors)

Source: Victorian Auditor-General's Office (2002).

The TAC is a 'no-fault' scheme; this means that medical benefits will be paid to an injured person regardless of who caused the accident. In relation to transferring costs to patients not covered by the TAC in Victoria (or an equivalent scheme in another state) there are two key options:

- assume care received is 'standard clinical practice' and thus apply to non-compensable patients; or
- adjust (decrease) costs for 'non-compensable' patients based on available evidence.

Previous literature indicates a lower utilisation of healthcare services by non-compensable patients. For example, Gabbe et al (2007) studied the healthcare service use of 243 blunt major trauma patients in Victoria over six months and found that:

- of patients with an ongoing disability, non-compensable patient were 3.7 times more likely to have ceased health care service use than compensable patients; and
- compensable patients were almost twice as likely to be discharged to inpatient rehabilitation (78% vs 40%).

In addition, VSTR data for TBI/SCI patients in 2007-08 confirms that non-compensable patients were approximately 20% less likely to be discharged to inpatient rehabilitation (Table 4-3).

TABLE 4-3: HEALTH SERVICE UTILISATION IN VICTORIAN TBI AND SCI MAJOR TRAUMA CASES BY COMPENSABLE/ROAD TRAUMA STATUS, 2007-08 (FREQUENCY AND (%))

Population descriptor		Traumatic Brain Injury		Spinal Cord Injury	
		Road trauma / Likely compensable (n=599)	Other / Likely non-compensable (n=637)	Road trauma / Likely compensable (n=42)	Other / Likely non-compensable (n=46)
Discharge status	n (%)				
	In-hospital death	57 (9.5)	94 (14.8)	5 (11.9)	12 (26.1)
	Home	199 (33.2)	265 (41.6)	8 (19.0)	10 (21.7)
	Inpatient rehabilitation	331 (55.3)	210 (33.0)	28 (66.7)	22 (47.8)
	Other	12 (2.0)	68 (10.7)	1 (2.4)	2 (4.3)
ICU stay	n (%)				
	Yes	331 (55.3)	218 (34.2)	19 (45.2)	19 (41.3)
ICU days**	Mean (SD)	8.0 (7.3)	6.8 (7.3)	9.4 (5.6)	8.5 (6.8)
Length of stay (days)	Mean (SD)	11.6 (12.2)	10.8 (14.2)	36.1 (59.1)	21.9 (30.4)

Source: VSTR (2009).

In light of this evidence, we assumed that TAC costs were not directly transferable to non-compensable patients. Consultation with experts indicated that 'acute care' costs are not likely to differ based on eligibility for compensation[14]. Therefore, adjustments were applied to the rehabilitation component of healthcare costs, equipment and modifications and long term care costs. There is no available empirical evidence regarding cost differences, therefore, costs for these categories were decreased by 30%[15] for non-compensable patients.

For Victoria, during the year 2007-08, 248 out of 477 (52%) TBI/SCI cases recorded on the VSTR were likely to be compensable by the TAC (Table 4-4). This figure was adopted for the Victorian analysis (Table 4-4).

[14] Best judgment by the steering committee convened for this project.
[15] Best judgment estimate by the steering committee convened for this project.

TABLE 4-4: PROPORTION OF VICTORIAN TBI/SCI CASES LIKELY TO BE 'COMPENSABLE'

Funding status	Traumatic Brain Injury		Spinal Cord Injury		Total
	Moderate	Severe	Paraplegia	Quadriplegia	
Total #	141	248	36	52	477
Likely compensable # *	65	141	19	23	248
Likely compensable %	46%	57%	53%	44%	52%

Source: VSTR (2009). Note: *A case was considered likely to be TAC compensable if the mechanism of injury was road trauma-related (i.e. motor vehicle, motorcycle, pedestrian, pedal cyclist, other transport-related) or confirmed as a TAC case according to the fund source recorded by the hospital.

For the Australian analysis, we assumed:

- Victoria, Tasmania and the Northern Territory have no-fault transport accident compensation schemes. For simplicity, this analysis assumed that the incident cases of TBI/SCI were evenly distributed across the states proportionally with population[16] and that proportion of 'compensable' cases in Tasmania and Northern Territory was equal to figures reported for Victoria (52%).
- In the remaining states and territories, 52% of TBI/SCI were assumed to be due to transportation accidents (source: VSTR 2009) and 60% of TBI/SCI cases were assumed to submit claims for compensation through common law schemes (refer to calculations in Table 4-5).
- Across all of Australia, 36.8%[17] of all TBI/SCI cases were assumed to be compensable.

TABLE 4-5: COMPARISON OF CLAIMS PER POPULATION BETWEEN STATES WITH COMMON LAW COMPENSATION SCHEMES AND VICTORIA

State	Total claims	Population	Claims per capita	Claims per 100,000 population
States with no fault compensation schemes				
NSW	4,918	6,984,172	0.07%	70
QLD	3,942	4,293,915	0.09%	92
SA	6,012	1,603,361	0.37%	375
Mean			0.18%	179
Comparison to Victoria				
VIC	16,047	5,313,823	0.30%	302
Mean for three states as % of Victoria				**60%**

Source: MAA (2008), MAC (2008), MAIC (2008) and TAC (2008).

Health outcomes data was assumed to be representative of the average TBI/SCI case and was thus assumed to be transferable to both compensable and non-compensable cases.

16 We acknowledge that in practice state-specific incidence is likely to vary. For example, in the three years 2003-04 to 2005-06, rates ranged from a high of 229 SCI cases per 100,00 of population in NT to a low of 117 cases per 100,000 in Victoria (AIHW, 2007).

17 Calculated as 52% transportation accidents*60%

Rehabilitation/long term healthcare costs, equipment/modifications and long term care costs were decreased by 30% for non-compensable patients.

The analysis assumed that 36.8% of all Australian and 52% of Victorian TBI/SCI cases were compensable.

Transferability across states

The TAC data relate to TBI/SCI patients in the state of Victoria. The modelling assumed that, for patients with the same condition and funding status, average unit costs from Victoria were transferable to other states/territories of Australia. Table 4-6 describes health service utilisation for TBI/SCI for three Australian states (Victoria, NSW and Queensland). The health service utilisation across states does not appear to be systematically different (i.e. consistently higher or lower for all conditions). Therefore using Victorian data to approximate other states appeared reasonable.

Table 4-6: Health service utilisation for TBI/SCI – Victoria, NSW and Queensland

Health service utilisation indicator	TBI		SCI	
	Moderate	Severe	Paraplegia	Quadriplegia
Mean length of acute stay				
Victoria	15.2	14.9	25.5	30.9
NSW	*	*	42	51
Queensland	13.9	21.5	21	39
Mean ICU days				
Victoria	8.1	7.7	9.5	8.8
NSW	*	*	*	*
Queensland	5.5	6.6	8	11

Source: VSTR (2009), QTR (2009), NSW SCIR (2009). *Not available.

Analysis assumed that Victorian unit cost data are transferable to other Australian states and territories.

Transferability to non MVA patients

To be eligible for TAC compensation, injuries of TBI/SCI patients must be due to an accident involving motorised land-based transport (train, bus, motorcycle, car, tram). The TAC costs sourced for this study are therefore reflective of the costs for TBI/SCI patients whose injuries are a consequence of transport accidents . Transferability of these costs to TBI/SCI patients with injures due to other causes (e.g. falls, water-related injuries) was uncertain.

Expert advice[18] indicates that treatment required for MVA (high velocity accidents) can differ from non-MVAs which tend to be lower velocity – for example, falls from ladders. However, there is no available evidence to support a cost differential. For simplicity, and in the context of scarce evidence, this analysis assumed that healthcare and associated costs were similar for the same conditions regardless of the cause.

[18] Source: Consultation with steering committee member Prof. Jamie Cooper

Analysis assumed that costs for injuries caused by MVA were transferable to injuries due to other causes.

5. HEALTH SYSTEM EXPENDITURE

This chapter estimates the Australian health system expenditure due to TBI/SCI. Health system expenditures include administration, ambulance/road accident rescue, hospital, medical and paramedical costs.

5.1 METHODS

There are essentially two ways of estimating health cost elements.

- **Top-down:** Data may be able to provide the total costs of a program element and then allocate those costs by disease. The AIHW estimates health system expenditure by disease or disease group, e.g. TBI or SCI.
- **Bottom-up:** Data may be available for the number of people with a disease who experience a cost impact from the disease ('n') and the average cost impact. The product is the total cost, e.g. the number of medical specialist visits to treat TBI/SCI in a year multiplied by the average cost of a specialist visit.

Due to the lack of national data and access to detailed TAC cost data, a bottom-up approach was employed for this analysis. The method for cost calculation is described in Chapter 4. An additional adjustment was performed as described in below. Healthcare utilisation for TBI/SCI was previously described in Section 2.4.

This analysis employs a bottom-up approach to costing.

Attribution issues

Patients with TBI/SCI are frequently multiple trauma patients. For example, in 2006-07 in Victoria the distribution of the number of injuries was:

- 24.8% of patients had one to two injuries;
- 22.4% had three to four injuries; and
- 52.8% had five or more injuries (VSTR, 2008).

Similarly, at a national level, NISU/AIHW published reports indicate that approximately 40-50% of all TBI/SCI cases do <u>not</u> indicate TBI/SCI as the principal diagnosis, suggesting multiple injuries.

- Of all TBI cases, 62.5% recorded a TBI code as the principal diagnosis (Helps et al, 2008).
- Of all SCI cases, 50.4% recorded a SCI code as the principal diagnosis (Henley, 2009).

It is therefore likely that some of the healthcare costs incurred by the TAC are attributable to other (typically orthopaedic) injuries. Consultation with the clinicians on the steering committee convened for this project indicated that costs are only likely to differ for the acute hospital period and not rehabilitation/ long term care. For estimation purposes, and following consultation with the steering committee, this analysis assumed that 50% of TBI/SCI cases have significant co-morbidities that would increase healthcare costs. For these cases, the acute hospital costs were decreased by 30%[19].

[19] Best judgment estimate by the steering committee convened for this project.

Analysis assumed that half of all TBI/SCI patients have co-morbidities that would require additional acute hospital costs. Acute hospital costs were reduced by 30% for these cases.

5.2 HEALTHCARE COSTS

The costs included with the healthcare cost category are summarised in Table 5-1.

TABLE 5-1: TAC HEALTHCARE COSTS – COSTS INCLUDED

Cost category	Costs included
Administration	Patient accommodation, parent expenses, information search costs and interpreter costs.
Ambulance/road accident rescue	Ambulance and road rescue.
Hospital	Acute, rehabilitation and other hospitals.
Medical	General practioners, specialist including anaesthetic and surgical doctors, pathology, radiology and psychiatry.
Paramedical	Dental, psychology, speech therapy, social work, physiotherapy, chiropody/podiatry, optical, chiropractor, osteopathy, special education, physical education, occupational therapy, nursing, chemist, driving education and serious injury family counselling.

Source: TAC (2009).

The healthcare costs calculated for TBI/SCI, disaggregated by years post injury, as used in the cost model are summarised in Table 5-2. Healthcare costs in the year of injury were highest for all conditions, except quadriplegia, for which healthcare costs peaked in year two. Mean per patient healthcare costs (Australia) for the first six years post injury ranged from $139,427 for moderate TBI to $297,453 for quadriplegia.

TABLE 5-2: TAC HEALTHCARE COSTS FOR MODEL, BY YEARS POST INJURY ($)

Year post injury	Moderate TBI	Severe TBI	Paraplegia	Quadriplegia
Australia				
1	86,679	112,394	89,744	87,642
2	35,621	69,132	64,685	120,073
3	5,908	16,794	18,344	37,850
4	5,054	9,584	9,102	17,567
5	2,544	8,213	7,184	13,817
6	2,413	6,830	8,058	13,669
>6	1,207	3,415	4,029	6,835
Total cost years 1-6	139,427	226,361	201,145	297,453
Victoria				
1	86,760	112,454	89,771	87,669
2	35,706	69,276	64,780	120,225
3	5,937	16,881	18,431	37,984
4	5,075	9,631	9,172	17,648
5	2,559	8,250	7,258	13,914
6	2,432	6,877	8,138	13,778
>6	1,216	3,438	4,069	6,889
Total cost years 1-6	138,469	223,369	197,549	291,218

Source: TAC (2009).

Table notes: With regards to hospital and medical consults, costs reflect full fees. In other words, no costs are absorbed by other funding agencies (e.g. Commonwealth through Medicare)

Hospital costs include all hospitals (acute/rehab, public/private).

Patients with less than one day in hospital must pay the first $564 in medical expenses (excess). This analysis assumes that the overwhelming majority of patient groups defined for this project would have been admitted for more than one day and thus no adjustment for this cost incurred by patients was necessary. This assumption was confirmed by TAC.

* For all years after year 6, constant costs were applied based on year 5 values and (year 4-6) cost trends.

Healthcare costs were estimated to be $269.1 million for moderate TBI and $308.0 million for severe TBI in Australia.

Healthcare costs were estimated to be $66.7 million for moderate TBI and $76.1 million for severe TBI in Victoria.

Healthcare costs were estimated to be $52.5 million for paraplegia and $76.5 million for quadriplegia in Australia.

Healthcare costs were estimated to be $13.5 million for paraplegia and $24.7 million for quadriplegia in Victoria.

6. PRODUCTIVITY AND OTHER FINANCIAL COSTS

In addition to health system costs, TBI and SCI also impose a number of other important financial costs on society and the economy. Because TBI and SCI typically affect young people of working age, most of these costs apply to them as well as to their family.

- **Equipment and modifications** are required to help manage disability from TBI and SCI to assist with daily living and transportation, avoid medical complications, and provide home assistance or ventilation.
- **Long term care costs** are incurred to provide services to people with SCI/TBI that would not be required in the absence of the injury, such as assisted accommodation, respite care, personal assistance, supported community services and living expenses.
- **Productivity losses** arise when people who would otherwise be employed are not able to work at all or work fewer hours because of their condition, or because they die prematurely as a result of their condition. Productivity losses also include absenteeism from work because of their condition.
- **Other costs** comprise the cost of aids and equipment, patient travel costs and other financial costs not captured elsewhere.
- **Efficiency losses** comprise the deadweight losses (DWLs) associated with government transfers such as taxation revenue forgone, welfare and disability payments.

6.1 EQUIPMENT AND MODIFICATIONS

Equipment and modifications are those not captured in formal health sector or disability services costs that include equipment and technology in order to assist with daily living.

Methods

The methods for cost calculation are described in Chapter 4.

TBI

The proportion of people with brain injury/acquired brain damage who used some form of aids was 47.7% in Victoria (SDAC 2009). TBI patients frequently require transportation equipment (e.g., prescription wheelchairs and gait aids) and environmental manipulation (e.g., installation of lifts, ramps and rails, and bathroom alterations). Patients with catastrophic injury may need prescription of major equipment (e.g., hoists to facilitate patient transfer, modifications to cars such as special seating) and modifications to their home environment (e.g., bathroom modifications, grab rails, non-skid flooring) (Khan 2003).

SCI

Patients with SCI typically used some form of assistant aid/device, equipment or home/vehicle modification as outlined below.

- **Transportation:** specialised vehicles, motorised wheelchairs, manual wheelchairs and crutches (Table 6-1).
- **Home assistance:** commode/shower chair on wheels, grab bar by the toilet, electrical bed, special mattress, lift/hoist, computers and kitchen tools or cutlery with special handles (Biering-Sørensen, 2004).

- **Avoid medical complications:** new mattresses, cushions, shower commodes, padded toilet seats, hoists and slings, electric beds and splints (QSCIS, 2001).
- **Ventilation:** Some people with quadriplegia require ventilation devices (which are extremely expensive).

TABLE 6-1: MOBILITY AIDS USED BY PEOPLE WITH SCI, BY SCI SEVERITY (%)

	Quadriplegia	Paraplegia
Crutch(es)	-	25.0
Rolling walker	-	33.3
Lower extremity braces	4.0	48.0
Standing frame	12.0	25.3
Stand-up wheelchair	25.0	37.5
Manual wheelchair	14.8	17.6
Sliding board	17.0	21.7
Wheel protector	18.0	21.0
Electrical wheelchair	31.0	9.8
Electrical scooter	6.0	31.3
Hand cycle	12.0	25.7
Arm braces	63.0	38.0
All participants	14.8	17.6

Source: Biering-Sørensen (2004).

Costs for TBI and SCI

The costs included with the equipment and modifications (E/M) cost category are summarised in Table 6-2.

TABLE 6-2: TAC EQUIPMENT AND MODIFICATION COSTS INCLUDED

Cost category	Costs included
Long term care other	Structural alterations, vehicle modification/purchase, computer equipment purchase, equipment for ADL, case management, community access planning/review and self purchasing/brokerage.
Vocational	Vocational equipment, education training courses and counselling.
Equipment	Beds, assisted movement, transport, communication aids, recreation, building fixtures, prosthesis and other.

Source: TAC (2009).

The costs for equipment and modifications (E/M) calculated for TBI/SCI disaggregated by years post injury utilised in the cost model are summarised in Table 6-3. Costs for E/M were highest in year two for all conditions. Mean per patient E/M for the first six years ranged from $8,381 for moderate TBI to $123,593 for quadriplegia. The costs for SCI were up to eight-fold the costs for TBI.

TABLE 6-3: TAC EQUIPMENT AND MODIFICATIONS COSTS FOR MODEL, BY YEARS POST INJURY ($)

Year post injury	Moderate TBI	Severe TBI	Paraplegia	Quadriplegia
Australia				
1	705	1,624	10,746	12,397
2	2,755	6,253	32,391	49,623
3	2,225	6,032	30,398	21,819
4	1,325	4,953	15,681	11,112
5	551	3,919	14,707	10,743
6	547	2,962	10,683	11,932
>6	273	1,481	5,342	5,966
Total cost years 1-6	8,381	27,225	119,949	123,593
Victoria				
1	745	1,716	11,351	13,095
2	2,910	6,605	34,215	52,417
3	2,350	6,372	32,109	23,048
4	1,399	5,232	16,564	11,738
5	582	4,140	15,535	11,348
6	578	3,129	11,285	12,604
>6	289	1,565	5,642	6,302
Total cost years 1-6	8,564	27,194	121,060	124,250

Source: TAC (2009). * For all years after year 6, constant costs were applied based on year 5 values and (year 4-6) cost trends.

Aids and modifications costs were estimated to be $59.7 million for moderate TBI and $158.5 million for severe TBI in Australia.

Aids and modifications costs were estimated to be $15.6 million for moderate TBI and $41.4 million for severe TBI in Victoria.

Aids and modifications costs were estimated to be $113.2 million for paraplegia and $113.6 million for quadriplegia in Australia.

Aids and modifications costs were estimated to be $30.4 million for paraplegia and $36.5 million for quadriplegia in Victoria.

6.2 LONG TERM CARE

Long term care costs (primarily attendant care) tend to be very high for TBI and SCI. It was therefore decided to include these as an individual cost category within the analysis.

Methods

The methods for cost calculation are described in Chapter 4.

Costs for TBI and SCI

The costs included with the long term care cost category are summarised in Table 6-4.

TABLE 6-4: TAC LONG TERM CARE COSTS – COST INCLUDED

Cost category	Costs included
Long term care	Attendant care, integration teacher aide, accommodation/respite care, independent living unit, special accommodation and nursing home supported community options.

Source: TAC (2009).

The costs for long term care calculated for TBI/SCI disaggregated by years post injury utilised in the cost model are summarised in Table 6-5. Costs for long term care increased rapidly in year 1 and 2 and then stabilised. Mean per patient long term care costs for the first six years ranged from $20,961 for moderate TBI to $343,526 for quadriplegia.

TABLE 6-5: TAC LONG TERM CARE COSTS FOR MODEL, BY YEARS POST INJURY ($)

Year post injury	Moderate TBI	Severe TBI	Paraplegia	Quadriplegia
Australia				
1	244	1,341	2,091	5,150
2	2,469	11,634	9,411	39,245
3	4,486	17,323	11,110	55,755
4	3,768	20,006	9,279	61,616
5	3,077	20,351	10,583	61,163
6	3,458	20,030	12,098	60,298
>6	3,458	20,030	12,098	60,298
Totalcostyears1-6	20,961	110,716	66,669	343,526
Victoria				
1	258	1,417	2,209	5,440
2	2,608	12,289	9,940	41,455
3	4,739	18,299	11,736	58,894
4	3,981	21,132	9,801	65,086
5	3,251	21,497	11,178	64,606
6	3,653	21,158	12,779	63,694
>6	3,653	21,158	12,779	63,694
Totalcostyears1-6	18,489	95,792	57,644	299,175

Source: TAC (2009). * For all years after year 6, constant costs were applied based on year 5 values and (year 4-6) cost trends.

Long term care costs were estimated to be $300.0 million for moderate TBI and $962.5 million for severe TBI in Australia.

Long term care costs were estimated to be $78.4 million for moderate TBI and $250.7 million for severe TBI in Victoria.

Long term care costs were estimated to be $109.4 million for paraplegia and $500.7 million for quadriplegia in Australia.

Long term care costs were estimated to be $29.3 million for paraplegia and $155.1 million for quadriplegia in Victoria.

6.3 PRODUCTIVITY LOSSES

Productivity losses represent the cost of production that is lost when people with TBI and SCI are unable to work because of their condition, work fewer hours than they otherwise would, are absent more often, are less productive while at work, or because they may die prematurely. Access Economics adopts a human capital approach to measurement of productivity losses in developed countries.

6.3.1 EMPLOYMENT PARTICIPATION

TBI and SCI can affect a person's ability to work. If employment rates for people with TBI and SCI post injury are lower than the employment rates among the general population, this loss represents a real cost to the economy. The employment (or participation) rate is calculated by dividing the total number of employed persons by the number of people in each age-gender group.

The Victorian DHS Disability Service Quarterly Data Collection Information System (DSQDC) and AIHW Commonwealth State/Territory Disability Agreement National Minimum Data Set (CSTDA NMDS) provide information about individuals' labour force participation decisions and employment of people with various types of illness (AIHW, 2007; DHS, 2008). However, only acquired brain injury (ABI) was most relevant to this study. TBI was not specifically spilt from ABI in the scope of illnesses collected by both datasets. In additional, neither dataset collects information for SCI.

Based on Victorian DSQDC data, 9.2% of males and 8.1% of females aged 15 years or older were employed. These calculations were based on all individuals who specified their employment status as either employed, unemployed or not in the labour force. The employment proportion was 26.1% and 20.3% for males and females respectively using the CSTDA NMDS data. The calculated proportion of individuals employed was quite different even though the same calculation approach was applied, reflecting the different populations in the different datasets.

International and national studies examining the employment status and labour force participation of people with TBI and SCI were therefore also examined and utilised.

TBI

Table 6-6 presents the list of existing articles and their findings for TBI that were most relevant to this report.

TABLE 6-6: SUMMARY OF EXISTING LITERATURE – TBI

Source	Data and sample	Findings
Ponsford et al (1995) and Olver et al (1996) – follow up study of Ponsford et al (1995)	Data obtained from Bethesda Hospital in Melbourne, Australia Sample included 254 patients, majority sustained moderate to severe TBI	Prior to injury – 68 persons were employed full time. Two years after injury – 41% of these 68 persons returned to full-time work, 9% to part-time work (total for full- and part-time of 50%), 43% were not employed and 7% were not in the labour force. Five years after injury – 34% returned to full-time work, 6% to part-time work (total for full-and part-time was 40%), 51% were not employed and 7% were not in the labour force. These figures translated to a probability of not being employed again after injury of about 50%-60% (include full- and part-time), mid point value of 55%.
Yasuda et al (2001)	Conducted a survey of numerous articles on persons with TBI	In general, post injury employment rates were in the range of 10%-70% compared to pre-injury employment rates of between 61% and 75%. Factors attributed to reduction in employment rates include injury severity, employment status definition and the absence of long-term follow up.
Boake et al (2005)	United States – 210 working-age adults with mild to moderate TBI who were employed prior to their injury	Moderate TBI patients – approximately 35% (i.e. 20 persons) were employed three months after injury. This figure increased to 40% three months later. Findings were consistent with existing literature such as Rimel et al (1982) and Dikmen et al (1994).

In order to calculate the productivity loss for people with TBI in Australia, the proportion of individuals with TBI who were employed was sourced from Ponsford et al (1995) and Olver et al (1996). Both articles utilised an Australia sample and their estimates were within the range specified in the international literature. Furthermore, unlike the disability services data from Victorian DHS and AIHW, Ponsford et al (1995) and Olver et al (1996) specifically looked at TBI patients. Unfortunately, Ponsford et al (1995) and Olver et al (1996) did not segregate their findings by severity of the condition.

SCI

Table 6-7 presents the list of existing articles and their findings for SCI that were most relevant to this report.

TABLE 6-7: SUMMARY OF EXISTING LITERATURE – SCI

Source	Data and sample	Findings
Murphy et al (1997)	Data obtained from Austin Hospital Spinal Injuries Unit in Melbourne, Australia Sample included 219 SCI patients of which 83% were male. Out of 219 patients, 98 suffered tetraplegia and 121 suffered paraplegia	Prior to the injury, 73% were employed (i.e. full- and part-time), 5% were unemployed and looking for work and the remainder were unemployed but not looking for work (i.e. not in the labour force) After sustaining injury, 37% were employed (i.e. full- and part-time), 4% were unemployed but looking for work and 59% were unemployed but not looking for work (i.e. not in the labour force)
Rowell and Connelly (2008)	Data obtained from Spinal Injuries Association (SIA), Queensland Sample included 181 patients with quadriplegia only	Used a newly developed spinal injuries survey instrument Prior to injury, 77.9% of the sample were employed, 5% were unemployed and looking for work and 8.6% were unemployed but not looking for work (i.e. not in the labour force) In the post injury period, 29.2% were employed, 11.1% were unemployed and looking for work and 54.2% were unemployed but not looking for work (i.e. not in the labour force)
Valtonen et al (2006)	182 Swedish patients with traumatic SCI who had been treated in the Spinal Injuries Unit in Sahlgrenska University Hospital, Göteborg, Sweden Majority of the interviewed patients were males (i.e. 73.6%)	Obtained responses using structured questionnaire Average pre-injury employment was found to be approximately 65.9% Average post injury employment was found to be approximately 47%

To calculate the productivity loss for people with SCI, the employment rate for individuals with paraplegia and quadriplegia was sourced from Murphy et al (1997). Although Rowell and Connelly (2008) provide an employment estimate specifically for individuals with quadriplegia, use of that estimate would suggest that the estimate from Murphy et al (1997) is an overestimate for individuals with paraplegia. The lack of reconciliation between the two sources is overcome by using the average employment rate from Murphy et al (1997) for individuals with paraplegia and quadriplegia. Moreover, unlike Valtonen et al (2006), Murphy et al (1997) used a sample from Australia which is more relevant to this report.

Excess

The excess in employment rates for individuals with TBI and SCI refers to the difference between the employment rates of these individuals and rates in the general population. This difference in employment rates can then be attributed to TBI and SCI respectively. The employment rates for the general population for Victoria and Australia were 62.0% and 62.4% respectively in 2008 (ABS, 2008). Because the rates were similar, the employment rate for Australia was used in the calculation for productivity loss only. Ideally, it is best to match age groups, but it was not possible in this case to age-standardise the difference, so the implicit assumption is that there is no substantial difference between the age distribution of the employed population and that of the TBI/SCI populations.

TBI. Taking the midpoint of the probability of not being re-employed after injury (i.e. 55%) as per Ponsford et al (1995) and Olver et al (1996) for both moderate and severe TBI, and multiplying by the Australian employment rate of 62.4% translates to an average reduction in the employment rate by 34.3% (i.e. 55.0% * 62.4%) for individuals with TBI in Australia (and Victoria). Note that the probability of not being re-employed after injury was assumed to be the same across genders (due to lack of ability to disaggregate the data).

SCI. As discussed earlier, the employment rates for individuals with paraplegia and quadriplegia were sourced from Murphy et al (1997). One problem that arises is the difference in employment rates between the sample (i.e. 73%) and the general population (i.e. 62.4%). Hence, the calculation for the excess takes the difference between the employment rates before and after sustaining injury, 36% (i.e. 73%-37%) and divides by 73% to obtain the probability of not being employed after sustaining injury, approximately 49.3% (i.e. 36%/73%). This then gives an average reduction in employment rate by 30.8% (i.e. 49.3% * 62.4%) for individuals with SCI in Australia (and Victoria). Note that, as with TBI, the probability of not being employed after injury was assumed to be the same across genders.

These results were then combined with average weekly earnings (AWE) and employment rates for each injury group to calculate the lost lifetime earnings in Australia and Victoria due to reduced employment in the modelling process.

> For Australia, the lifetime lost earnings due to reduced employment are estimated as:
>
> - moderate TBI = $452.9 million; severe TBI = $256.3 million; paraplegia = $47.8 million and quadriplegia = $43.8 million.
>
> For Victoria, the lifetime costs of lost earnings due to reduced employment are estimated as:
>
> - moderate TBI = $119.0 million; severe TBI = $70.5 million; paraplegia = $12.5 million and quadriplegia = $12.7 million.

These results are consistent with the epidemiology of TBI and SCI – in that it can be a debilitating condition significantly reducing the ability to participate in employment.

6.3.2 ABSENTEEISM FROM PAID AND UNPAID WORK

Absenteeism is unlikely to represent a significant component of the productivity losses associated with TBI and SCI. This is because only moderate and severe TBI and SCI are examined in this report, and many people with these injuries were unable to return to work (Ponsford et al, 1995; Olver et al, 1996; Murphy et al, 1997; Engel et al, 1998; Boake et al, 2005; Wehman et al, 2005; Pflaum et al, 2006; Valtonen et al, 2006; Rowell and Connelly, 2008).

- For those who managed to return to work after sustaining an injury, the scope of their job and their duties may have changed and been tailored to their needs. For instance, Schönherr et al (2004) found that in the majority of work situations for people with SCI, modifications were made such as job adaptations and a reduction in working hours. In particular, for those who resumed work, 61% kept working for the same employer but nearly half of them changed to a different type of job. The remaining 39% did not return to the same employer. The sample consisted of 57 people who were admitted to Centre for Rehabilitation Beatrixoord, The Netherlands.

- In another example, Ponsford et al (1995) showed that out of 25 people with TBI who were employed full time after sustaining their injury, 16 had returned to their previous position with the same duties, four had alternative duties with their previous employer, five had returned to full-time work with a new employer and one returned to a previous position on a part-time basis.

Hence, based on this literature, the largest component of the loss of productivity due to TBI and SCI appears to derive from reduced employment rather than absenteeism.

While there is a lack of literature quantifying absenteeism, one possible way to calculate the cost of absenteeism is to use the eligibility criteria in gaining compensation benefits as a guide. For instance, in Victoria, individuals who suffered a loss of earnings (LOE) as a result of their transport accident injury could gain access to LOE benefits from the TAC. These individuals had to be working at the time of the accident, aged 15 years or older and their injuries prevented them from returning to work. However, individuals who qualified for an LOE benefit also had to wait for the "first five days" exclusion period to end before their LOE payments could commence. During these five days, individuals are expected to use their own funds or sick leave entitlements from their employers.[20]

Therefore, to quantify the lifetime cost of absenteeism, five days of sick leave per person was assumed to have been taken by injured patients who were employed prior to their injury. This assumption was applied to individuals with moderate/severe TBI, paraplegia and quadriplegia.

The same number of days lost was estimated for those who do *not* work in paid employment, from their household productivity, which is typically valued at 30% of the average wage rate.

> Based on these parameters and the AWE for each age-gender group, Access Economics estimates that in 2008, for Australia, the total lifetime costs of absenteeism from paid and unpaid work are:
>
> - moderate TBI = $0.9 million; severe TBI = $0.6 million; paraplegia = $0.1 million and quadriplegia = $0.1 million.
>
> For Victoria, the total lifetime costs of absenteeism from paid and unpaid work are approximately:
>
> - moderate TBI = $0.3 million; severe TBI = $0.2 million; paraplegia = $30,260 and quadriplegia = $41,847.

6.3.3 Premature death

From the mortality rates in Section 2.5, there were an estimated 337, 351, 9 and 19 deaths due to moderate TBI, severe TBI, paraplegia and quadriplegia in Australia. The number of deaths were 84, 87, 2 and 7 respectively for Victoria. In Australia, based on this case mortality risk, and incorporating the employment rates and estimates of average lifetime

[20] Information obtained from TAC website: **www.tac.vic.gov.au**. Last accessed at 21 April 2009.

earnings for different age-gender groups, the present values of lost lifetime earnings due to premature death among those who would otherwise have been employed are $243.4 million, $253.3 million, $6.8 million and $14.3 million for moderate/severe TBI, paraplegia and quadriplegia respectively. In Victoria, the figures are $63.7 million, $69.4 million, $1.8 million and $4.1 million respectively.

Premature death also leads to additional search and hiring costs for replacement workers. These are estimated as the number of people with moderate TBI, severe TBI, paraplegia and quadriplegia who die prematurely (by age and gender) multiplied by their chance of being employed multiplied by the search and hiring cost brought forward three years where the search and hiring cost is estimated as 26 weeks at AWE and the three year bring forward reflects average staff turnover rates in Australia.

Therefore, in Australia, the average additional search and hiring lifetime costs are estimated at approximately $0.9 million, $0.7 million, $0.1 million and $0.1 million for moderate/severe TBI, paraplegia and quadriplegia respectively. The figures are $0.3 million, $0.2 million, $26,981 and $38,578 respectively for Victoria.

6.4 CARER COSTS

Carers are people who provide informal care to others in need of assistance or support. Most informal carers are family or friends of the person receiving care. Carers may take time off work to accompany people with TBI and SCI to medical appointments, stay with them in hospital, or care for them at home. Carers may also take time off work to undertake many of the unpaid tasks that the person with TBI and SCI would do if they did not sustain injuries and were able to do these tasks.

Informal care is distinguished from services provided by people employed in the health and community sectors (formal care) because the care is generally provided free of charge to the recipient and is not regulated by the government.

While informal care is provided free of charge, it is not free in an economic sense, as time spent caring is time that cannot be directed to other activities such as paid work, unpaid work (such as housework or yard work) or leisure. As such, informal care is a use of economic resources.

6.4.1 METHODOLOGY

There are three potential methodologies that can be used to place a dollar value on the informal care provided.

- **Opportunity cost** is the value of lost wages forgone by the carer.
- **Replacement valuation** is the cost of buying a similar amount of services from the formal care sector.
- **Self-valuation** is what carers themselves feel they should be paid.

Access Economics has adopted the opportunity cost method in this report as it provides the most accurate estimate of carer costs based on AWE and sufficient demographic data are available on providers of care for people with TBI and SCI.

6.4.2 INFORMAL CARE COSTS ESTIMATION

This report analyses the available epidemiological data (from Australia and overseas) together with Survey of Disability, Ageing and Carers (SDAC), Victorian DSQDC and CSTDA

NMDS data (ABS, 2003; AIHW, 2007; DHS, 2008) and Access Economics (2005), to gain estimates of the proportion of individuals who had a carer and the total number of hours of care provided to people with TBI and SCI in 2008. The value of care is then calculated based on AWE and the average probability of employment.

TBI

Data from Australasian Rehabilitation Outcomes Centre (AROC), SDAC, Victorian DSQDC, CSTDA NMDS provided information on informal care used by people with brain injury or ‘acquired brain damage’. As noted earlier, data for ABI were assumed to be transferable to TBI.

According to AROC data, the proportion of people requiring external support increased substantially after TBI/SCI. For instance, the proportion of patients who required external support prior to their injury was 39% and this figure increased to 76% after injury and patients were discharged from the hospital (AROC, 2008).

SDAC data on the other hand specifically provide the proportion of injured people who have informal assistance[21]. In Victoria, the proportion of people with brain injury/acquired brain damage with informal assistance was 52.1%. The proportion was 53.6% for Australia. These proportions were very similar to those obtained from Victorian DSQDC and CSTDA NMDS data, where the proportions of individuals with ‘acquired head injury’ who have informal carers were 54.2% and 50.1% respectively. Given the similarity across datasets, the proportion obtained from SDAC (i.e. 53.6%) was utilised for both Victoria and national level economic modelling since it represented the mid value across all the range of figures obtained from the available data.

Based on the Victoria DSQDC data, it was further revealed that out of those who have informal carers, 58.6% have carers of primary status. This implied that there were approximately 31.4% (i.e. 58.6%*53.6%) who had an informal carer with primary status. This proportion was high compared to approximately 2.4% of the general population who have primary carers (ABS, 2003). Taking the difference between 31.4% and 2.4% gives the total ‘excess’ of informal care use attributable to brain injury, i.e. 29.0%.

To obtain the number of hours spent by primary carers on patients with TBI, inference was made based on the GOS-E severity scale and the number of hours spent by primary carers on patients with paraplegia and quadriplegia. As discussed further in the next sub-section, the average number of hours spent caring for people with paraplegia and quadriplegia was 22.9 and 40 hours per week respectively. Bearing this in mind and looking at the frequency distribution of patients with TBI and SCI on the GOS-E scale, it was revealed that most patients with severe TBI were the same severity scale as patients with paraplegia (Table 6-8). Using this relationship, the same number of hours was assumed for individuals with severe TBI, i.e. 22.9 hours.

Most patients with moderate TBI, unsurprisingly, were a scale lower than those with severe TBI. To be conservative with the estimates of carer costs for this group, the number of hours provided by primary carers was assumed to be half of those with severe TBI

[21] According to ABS, informal assistance is defined as unpaid help or supervision that is provided to persons with one or more disabilities or persons aged 60 years and over living in households. It includes only assistance that is provided for one or more of the specified tasks comprising an activity because of a person's disability or age. Informal assistance may be provided by family, friends or neighbours. For this survey, any assistance received from family or friends living in the same household, was considered to be informal assistance regardless of whether or not the provider was paid (ABS, 2003).

i.e. approximately 11.4 hours (50%*22.9 hours). Note that the same average hours per week were assumed to apply to male and females patients with TBI.

Table 6-8: The highest frequency of patients with TBI and SCI that occurred on the GOS-E scale

GOS-E	Moderate TBI	Severe TBI	Paraplegia	Quadriplegia
Death				
Vegetative state				
Lower severe disability				✓
Upper severe disability		✓	✓	
Lower moderate disability	✓			
Upper moderate disability				
Lower good recovery				
Upper good recovery				

Source: Victorian Trauma Registry (2008).

Finally, the cost of non-primary carers for patients with TBI was assumed to be 41.9% of total primary carer costs. This proportion was based on the findings in Access (2005).

> Based on these parameters and the AWE for each age-gender group, Access Economics estimates that in 2008, the total lifetime carer costs in Australia are approximately:
>
> - moderate TBI = $25.1 million and severe TBI = $28.5 million.
>
> The total lifetime carer costs in Victoria are approximately:
>
> - moderate TBI = $6.6 million and severe TBI = $7.5 million.

SCI

Similar to patients with TBI, the proportion of patients with paraplegia and quadriplegia that required external support increased drastically prior to and after sustaining injury (AROC, 2008). For instance, the proportion of patients with paraplegia and quadriplegia who required external support prior to their injury was 28% and 33% respectively. The figures increased to 69% and 80% after injury and patients were discharged from the hospital (AROC, 2008).

According to SDAC data, the proportion of individuals in Australia who have paralysis with a disability and have some form of informal assistance was approximately 79.3% (ABS, 2003). Unfortunately, due to the small number of cases, ABS was unable to provide further information. Fortunately, international and national literature considered the role of carers for people with paraplegia and quadriplegia.

- Rowell and Connelly (2008) found that families played an ongoing role caring for people with SCI. A total of 70% of 181 individuals (in Queensland, Australia) with quadriplegia received some unpaid care. The average number of hours spent by caregivers was found to be approximately 80 hours per fortnight (i.e. 40 hours per week).

- Using a sample of 348 US veterans (345 men, 3 women) with paraplegia (51%) and tetraplegia (49%), Robinson-Whelen and Rintala (2003) found that 38% received no paid or unpaid assistance/carer while another 37% received some form of unpaid assistance/care. The remaining received paid care only. They also found that on average, primary informal caregivers provided almost 12 hours of care per day. The average hours were approximately 14 hours for quadriplegia and 8 hours for paraplegia (i.e. approximately 57.1% of the number of hours spent on patients with quadriplegia).

In order to calculate the carer costs, the proportion of individuals with quadriplegia with a primary carer was assumed to be 70% as found by Rowell and Connelly (2008) – possibly conservative since it is lower than SDAC (i.e. 79.3%). This Rowell and Connelly (2008) source appears reasonable given that the average number of hours spent by carers was equivalent to those spent in a full time job. The same proportion was applied to patients with paraplegia. The number of hours spent by primary carers caring for people with paraplegia was, however, adjusted by a factor of 57.1% as indicated in Robinson-Whelen and Rintala (2003) and this gave an average hour of 22.9 per week (i.e. 57.1%*40 hours per week). Note that the same average hours per week were assumed to apply to male and females patients with SCI.

Finally, the cost of non-primary carers for patients with SCI was again assumed to be 41.9% of total primary carer costs (Access Economics, 2005).

Based on these parameters and the AWE for each age-gender group, Access Economics estimates that in 2008, the total lifetime carer costs in Australia are approximately:

- paraplegia = $9.1 million and quadriplegia = $14.6 million.

The total lifetime carer costs in Victoria are approximately:

- paraplegia = $2.4 million and quadriplegia = $4.8 million.

6.5 FUNERAL COSTS

The 'additional' cost of funerals borne by family and friends of people with TBI and SCI is based on the additional likelihood of deaths associated with TBI and SCI (Section 6.3.3) in the period that the person is injured. However, some patients (particularly older patients) would have died during this time anyway. Eventually everyone must die and thus incur funeral expenses – so the true cost is the cost brought forward (adjusted for the likelihood of dying anyway in a given year). The Bureau of Transport Economics (2000) calculated a weighted average cost of a funeral across all states and territories, to estimate an Australian total average cost of $3,200 per person for 1996, or, inflated using consumer price inflation, **$4,380 per person who died in 2008**.

In Australia, the **bring forward of funeral costs** associated with premature death are approximately:

Moderate TBI = $0.7 million; severe TBI = $0.7 million; paraplegia = $17,917 and quadriplegia = $38,034.

In Victoria, the **bring forward of funeral costs** associated with premature death are approximately:

Moderate TBI = $0.2 million; severe TBI = $0.2 million; paraplegia = $4,591 and quadriplegia = $12,319.

6.6 DEADWEIGHT LOSSES FROM TRANSFERS

Transfer payments represent a shift of resources from one economic entity to another. The act of taxation and redistribution creates distortions and inefficiencies in the economy hence transfers also entail real net costs to the economy. These real net costs are termed 'deadweight losses (DWLs)'.

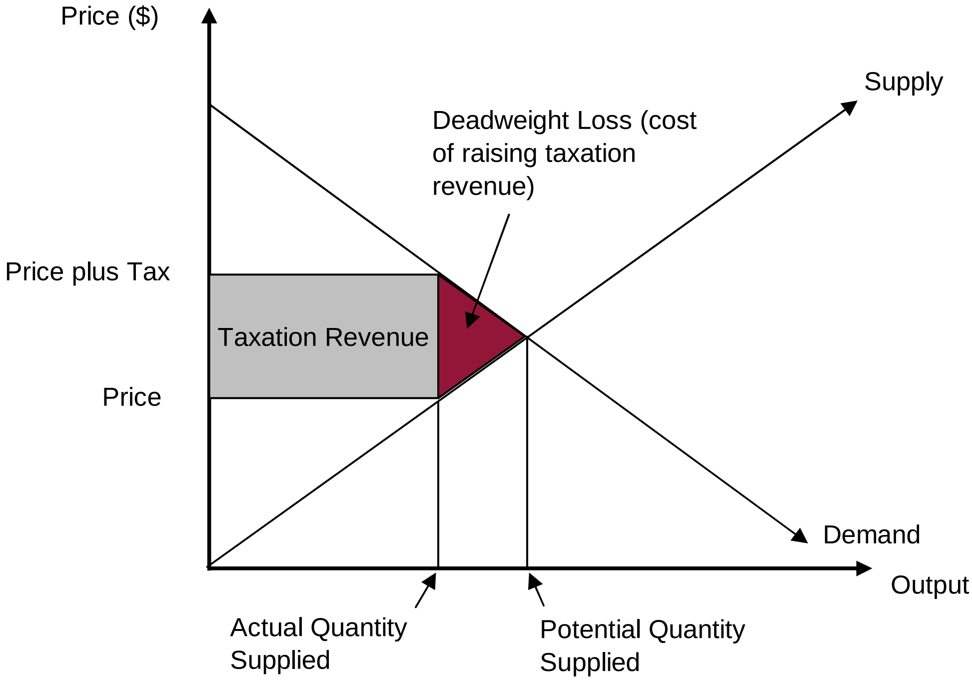
DWLs refer to the costs of administering welfare pensions and raising additional taxation revenues. Although invalid and sickness benefits and forgone taxation are transfers, not real costs (so should not be included in the estimation of total costs), it is still worthwhile estimating them as that helps us understand how the total costs of TBI and SCI are shared between the taxpayer, the individual and other financiers.

There are two sources of lost tax revenue that result from the lower earnings – the potential income tax forgone and the potential indirect (consumption) tax forgone. The latter is lost because, as income falls, so does consumption of goods and services. The average personal income tax rate used is 18.7% and the average indirect taxation rate used is 13.1%, based on parameters for 2008 from the Access Economics macroeconomic model.

Transfer payments (Government payments/services and taxes) are not a net cost to society as they represent a shift of consumption power from one group of individuals to another in society. If the act of taxation did not create distortions and inefficiencies in the economy, then transfers could be made without a net cost to society. However, through these distortions, taxation does impose a DWL on the economy.

DWL is the loss of consumer and producer surplus, as a result of the imposition of a distortion to the equilibrium (society preferred) level of output and prices. Taxes alter the price and quantity of goods sold compared to what they would be if the market were not distorted, and thus lead to some diminution in the value of trade between buyers and sellers that would otherwise be enjoyed (Figure 4-2).

FIGURE 6.1: DWL OF TAXATION



The rate of DWL used in this report is 27.5 cents per $1 of tax revenue raised plus 1.25 cents per $1 of tax revenue raised for Australian Taxation Office administration, based on Productivity Commission (2003) in turn derived from Lattimore (1997), ie, 28.75% overall. The total extra tax dollars required to be collected include:

- the taxation revenue lost as a result of the impact of TBI and SCI on the employment rates of those affected; and
- the additional induced social welfare payments required to be paid.

6.6.1 LOST TAXATION REVENUE

Reduced earnings due to reduced workforce participation, absenteeism and premature death also have an effect on taxation revenue collected by the Government. As well as forgone income (personal) taxation, there will also be a fall in indirect (consumption) tax, as those with lower incomes spend less on the consumption of goods and services.

Personal income tax forgone is a product of the average personal income tax rate (18.7%) and the forgone income. With TBI and SCI and lower income, there will be less consumption of goods and services, with the indirect taxation rate estimated as 13.1%. These average taxation rates are derived for 2008 from the Access Economics macroeconomic model.

Access Economics estimates the following deadweight losses incurred in 2008 in Australia, due to additional taxation to replace that forgone due to lost production of people with TBI and SCI.

Moderate TBI = $66.1 million; severe TBI = $49.3 million; paraplegia = $5.8 million and quadriplegia = $6.7 million.

For Victoria, the deadweight losses are estimated below.

Moderate TBI = $17.4 million; severe TBI = $13.5 million; paraplegia = $1.5 million and quadriplegia = $2.0 million.

6.6.2 SOCIAL WELFARE PAYMENTS

Welfare payments made to people who are no longer working must, in a budget-neutral setting, also be funded by additional taxation.

Under the government-funded Disability Support Pension (DSP) scheme, those unable to work or to be retrained to work for at least 15 hours per week within two years because of illness, injury or disability, receive some level of financial support. Pension payments operate on a sliding scale and depend on earnings from employment. The maximum available pension is currently $569.80 per fortnight and assumes no income from employment.[22]

To estimate the DWL, the welfare payments paid need to be calculated. The following method and assumptions are carried out and made.

- To be conservative, no DSP was assumed to apply to compensable patients who were eligible for some form of compensation from TAC-like programs (i.e. in Victoria, NT and Tasmania). This was because there was no certainty regarding the implications of TAC compensation on patient eligibility for Commonwealth DSP.
- According to the DHS disability support database, 80% of the individuals who were not employed or not in labour force received DSP. This proportion was assumed to apply to all non-compensable patients with moderate/severe, paraplegia and quadriplegia who were not employed or not in the labour force.
- Finally, for those who received DSP, it was assumed that they received the maximum threshold of $569.80 per fortnight.

[22] More information could be found at Centrelink website at www.centrelink.gov.au, last accessed on 30 April 2009.

> Access Economics estimates the following deadweight losses incurred in 2008 in Australia, due to welfare payments (i.e. DSP plus TAC-like payments adjusted using population figures) for people with TBI and SCI.
>
> Moderate TBI = $55.4 million; severe TBI = $40.4 million; paraplegia = $13.8 million and quadriplegia = $19.7 million.
>
> For Victoria, the deadweight losses are estimated below.
>
> Moderate TBI = $6.9 million; severe TBI = $10.4 million; paraplegia = $1.9 million and quadriplegia = $2.5 million.

- Additional DWLs are associated with other government payments (Table 6-9).

6.7 SUMMARY OF OTHER FINANCIAL COSTS

In total, the non-health related financial costs of TBI and SCI are estimated to be $1,589.0 million and $208.4 million respectively in 2008 in Australia

For Victoria, the respective figures are $413.1 million and $53.6 million.

TABLE 6-9: SUMMARY OF OTHER LIFETIME FINANCIAL COSTS OF TBI AND SCI ($) MILLION

	Moderate TBI	Severe TBI	Total TBI	Para-plegia	Quad-riplegia	Total SCI	Grand total
Australia:							
Productivity costs							
Employment	452.9	256.3	709.2	47.8	43.8	91.6	800.8
Absenteeism	0.9	0.6	1.4	0.1	0.1	0.2	1.7
Searching/hiring	0.9	0.7	1.6	0.1	0.1	0.2	1.8
Premature death	243.4	253.3	496.7	6.8	14.3	21.1	517.8
Carers	25.1	28.5	53.5	9.1	14.6	23.8	77.3
Funeral costs	0.7	0.7	1.4	0.0	0.0	0.1	1.5
DWL	174.6	150.5	325.1	30.0	41.5	71.5	396.6
Total	898.5	690.5	1,589.0	93.9	114.6	208.4	1,797.4
Victoria:							
Productivity costs							
Employment	119.0	70.5	189.5	12.5	12.7	25.2	214.7
Absenteeism	0.3	0.2	0.5	0.0	0.0	0.1	0.5
Searching/hiring	0.3	0.2	0.5	0.0	0.0	0.1	0.6
Premature death	63.7	69.4	133.1	1.8	4.1	5.9	139.0
Carers	6.6	7.5	14.1	2.4	4.8	7.2	21.3
Funeral costs	0.2	0.2	0.4	0.0	0.0	0.0	0.4
DWL	36.8	38.2	75.0	6.0	9.1	15.1	90.2
Total	226.9	186.2	413.1	22.8	30.8	53.6	466.7

Note: * denotes figures in dollars. Calculations may not reconcile due to rounding.

Source: Access Economics calculations.

7. BURDEN OF DISEASE

A substantial cost of TBI and SCI is the loss of wellbeing and life expectancy that patients experience. This chapter estimates the 'burden of disease' (BoD) of TBI and SCI in Australia, measured in terms of disability adjusted life years (DALYs), which is the sum of healthy years of life lost due to disability (YLD) and years of life lost due to premature death (YLL). The BoD was converted into a monetary equivalent using an imputed value of a statistical life year (VSLY), to enable comparison between the BoD and the financial costs of TBI and TSCI.

7.1 METHODOLOGY – VALUING LIFE AND HEALTH

7.1.1 MEASURING BURDEN: DALYS, YLLS AND YLDS

In the last decade, a non-financial approach to valuing human life has been derived, where loss of wellbeing and premature mortality – called the 'burden of disease and injury' – are measured in terms of Disability Adjusted Life Years, or DALYs. This approach was developed by the World Health Organization (WHO), the World Bank and Harvard University for a study that provided a comprehensive assessment of mortality and disability from diseases, injuries and risk factors in 1990, projected to 2020 (Murray and Lopez, 1996). Methods and data sources are detailed further in Murray et al (2001) and the WHO continues to update the estimates.

A DALY of 0 represents a year of perfect health, while a DALY of 1 represents death. Other health states are attributed values between 0 and 1 as assessed by experts on the basis of literature and other evidence of the quality of life in relative health states. For example, the *disability weight* of 0.18 for a broken wrist can be interpreted as losing 18% of a person's quality of life relative to perfect health, because of the inflicted injury. Each year of life lost due to premature death attributable to the condition under review is also equivalent to one DALY. Total DALYs lost from a condition are the sum of – year(s) of healthy life lost due to disability (YLDs) and the year(s) of life lost due to premature death (YLLs).

The DALY approach has been successful in avoiding the subjectivity of individual valuation and is capable of overcoming the problem of comparability between individuals and between nations. This report treats the value of a life year as equal throughout the lifespan.

As these approaches are not financial, they are not directly comparable with most other cost and benefit measures. In public policy making, it is often desirable to apply a monetary conversion to ascertain the cost of an injury, disease or fatality or the value of a preventive health intervention, for example, in cost benefit analysis. Such financial conversions tend to utilise 'willingness to pay' concepts from risk-based labour market and other studies, as described in the next section.

7.1.2 WILLINGNESS TO PAY AND THE VALUE OF A STATISTICAL LIFE YEAR

The burden of disease as measured in DALYs can be converted into a dollar figure using an estimate of the **Value of a 'Statistical' Life** (VSL). As the name suggests, the VSL is an estimate of the value society places on an anonymous life. Since Schelling's (1968) discussion of the economics of life saving, the economic literature has focused on **willingness to pay** (WTP) – or, conversely, willingness to accept – measures of mortality and morbidity, in order to develop estimates of the VSL.

Estimates may be derived from observing people's choices in situations where they rank or trade off various states of wellbeing (loss or gain) either against each other or for dollar amounts e.g. stated choice models of people's WTP for interventions that enhance health. Alternatively, risk studies use evidence of market trade-offs between risk and money, including numerous labour market and other studies (such as installing smoke detectors, wearing seatbelts or bike helmets and so on).

The extensive literature in this field mostly uses econometric analysis to value mortality risk and the 'hedonic wage' by estimating compensating differentials for on-the-job risk exposure in labour markets; in other words, determining what dollar amount would be accepted by an individual to induce him/her to increase the probability of death or morbidity by a particular percentage.

As DALYs are enumerated in years of life rather than in whole lives it is necessary to calculate the **Value of a 'Statistical' Life Year (VSLY)** based on the VSL. This is done using the formula:[23]

$$VSLY = VSL \;/\; \Sigma_{i=0,\dots,n-1}(1+r)^{i}$$

Where: n = years of remaining life, and
r = discount rate

Clearly there is a need to know *n* (the years of remaining life), and to determine an appropriate value for *r* (the discount rate). There is a substantial body of literature, which often provides conflicting advice, on the appropriate mechanism by which costs should be discounted over time, properly taking into account risks, inflation, positive time preference and expected productivity gains. In reviewing the literature, Access Economics (2008) found the most common rate used to discount healthy life was 3%. This report assumes a discount rate for future streams of health in Australia of 3%. Access Economics (2008) recommended an average VSL of $6.0 million in 2006 Australian dollars ($3.7 million to $8.1 million).

- This equates to an average VSLY in 2006 of $252,014 ($155,409 to $340,219), using a discount rate of 3% over an estimated 40 years remaining life expectancy[24].
- Inflating the 2006 VSLY value to 2008 dollars by multiplying it by two years of inflation (2.9% in each year, from the Access Economics Macroeconomic model) results in a base case of $266,843 with lower and upper bounds of $164,553 and $360,238.
- However, from this gross value, Access Economics deducts all costs borne by the individual, reflecting the source study VSL estimates, to avoid double counting. This provides a different net VSLY for different conditions (and for different age-gender groups).

Since Access Economics (2008) was published, the Department of Finance and Deregulation have also provided an estimate of the VSLY, which appears to represent a fixed estimate of the net VSLY. This estimate was $151,000[25] in 2006, which inflates to $157,795 in 2008 dollars. This is very similar to the average net VSLY estimated using the Access Economics (2008) meta-analysis, and is used in calculations for the modelling here.

[23] The formula is derived from the definition:
VSL = ΣVSLYi/(1+r)^^{i} where i=0,1,2….n
where VSLY is assumed to be constant (ie, no variation with age).

[24] This assumption relates to the average years of life remaining for people included in VSL studies, not the years of life remaining for people with TBI and SCI.

[25] http://www.finance.gov.au/obpr/cost-benefit-analysis.html

7.2 BURDEN OF DISEASE

7.2.1 DISABILITY WEIGHTS

SCI

The most comprehensive source of disability weights in Australia is the AIHW burden of disease report (Begg et al, 2007). As shown in Table 7-1, this report described disability weights for paraplegia and quadriplegia and these weights were adopted for analysis within this report. Note that weights were not available by age and gender and therefore were standardised across all demographic groups.

TABLE 7-1: DISABILITY WEIGHTS FOR SCI

Injury	Severity level, stage or sequelae	Disability weight	Source
Injured spinal cord	Paraplegia	0.570	Dutch weight
	Quadriplegia	0.840	Dutch weight

Source: AIHW burden of disease report (Begg et al, 2007).

TBI

The AIHW burden of disease report (Begg et al, 2007) reported disability weights for brain injury, although not disaggregated by severity as is required for this report[26].

External literature was reviewed to identify TBI disability weights broken down by severity classification. Haagsma et al (2008) reported weights for moderate and severe brain injury which were adopted for this analysis (Table 7-2).

TABLE 7-2: DISABILITY WEIGHTS FOR TBI

Injury	Disability weight
Moderate brain injury	0.193
Severe brain injury, stable	0.429

Note: Haagsma et al (2008) also included an acute disability weight for severe brain injury for the first year of injury (i.e. 0.540). However, the impact of the difference in weights is likely to be small hence only the stable disability weight for severe brain injury is utilised in the burden of disease estimation.
Source: Haagsma et al (2008).

Following the findings from Haagsma et al (2008), the disability weights utilised in the burden of disease estimation were 0.193 and 0.429 for moderate and severe brain injury respectively.

7.2.2 YEARS OF LIFE LOST DUE TO DISABILITY

Based on the disability weights outlined above and the total number of people experiencing TBI and SCI, the YLD for TBI and SCI have been calculated (Table 7-3), for the year 2008.

---

[26] TBI disability weights are reported for short and long term injuries. Both moderate and severe TBI were considered to be long term conditions.

> In total, YLDs for TBI and SCI were an estimated 15,703 and 4,487 DALYs respectively in 2008 for Australia. The figures are 3,979 and 1,298 respectively for Victoria.

TABLE 7-3: ESTIMATED YEARS OF HEALTHY LIFE LOST DUE TO DISABILITY (YLD), 2008 (DALYS)

	Moderate TBI	Severe TBI	Total TBI	Para-plegia	Quad-riplegia	Total SCI	Grand total
Australia:							
YLD	6,466	9,237	15,703	1,839	2,648	4,487	20,190
Victoria:							
YLD	1645	2,334	3,979	471	827	1,298	5,277

Source: Access Economics calculations.

7.2.3 YEARS OF LIFE DUE TO PREMATURE DEATH

Based on the relative risk of mortality due to TBI and SCI outlined above in Section 2.5, there are an estimated 337, 351, 9 and 19 deaths due to moderate/severe TBI, paraplegia and quadriplegia respectively in Australia in 2008. The estimated number of deaths for Victoria was 84, 87, 2 and 7 respectively. YLLs have been estimated from the age-gender distribution of deaths by the corresponding YLLs for the age of death in the Standard Life Expectancy Table (West Level 26) with a discount rate of 3.0% and no age weighting.

> In Australia, YLLs for TBI and SCI were an estimated 15,341 and 603 DALYs respectively in 2008. The figures were 3,859 and 177 respectively for Victoria (Table 7-4).

TABLE 7-4: YEARS OF LIFE LOST DUE TO PREMATURE DEATH (YLL) DUE TO TBI AND SCI, 2008

	Moderate TBI	Severe TBI	Total TBI	Para-plegia	Quad-riplegia	Total SCI	Grand total
Australia:							
YLL	7,518	7,823	15,341	193	410	603	15,943
Victoria:							
YLL	1,894	1,965	3,859	49	127	177	4,036

Source: Access Economics calculations.

7.2.4 TOTAL DALYS DUE TO SCI AND TBI

In Australia, the overall loss of wellbeing due to TBI and SCI is estimated as 31,044 and 5,090 DALYs respectively whereas in Victoria alone, the overall loss of wellbeing due to TBI and SCI is estimated as 7,838 and 1,475 DALYs respectively.

TABLE 7-5: DISABILITY ADJUSTED LIFE YEARS (DALYS) DUE TO TBI AND SCI, 2008

	Moderate TBI	Severe TBI	Total TBI	Para-plegia	Quad-riplegia	Total SCI	Grand total
Australia:							
DALYs	13,984	17,060	31,044	2,032	3,058	5,090	36,133
Victoria:							
DALYs	3,539	4,299	7,838	520	954	1,475	9,313

Multiplying the number of DALYs by the VSLY ($157,795) provides an estimate of the dollar value of the loss of wellbeing due to TBI and SCI.

For Australia, the estimated cost of lost wellbeing from TBI and SCI is $4.9 billion and $803.2 million respectively in 2008. This reflects the incidence of TBI and SCI in the community and its relatively high disability weights.

For Victoria, the estimated cost of lost wellbeing was $1.2 billion and $233 million respectively.

8. SUMMARY AND COMPARISON

8.1 COSTS FOR AUSTRALIA

TBI

The total cost of **TBI** in Australia was estimated to be $8.6 billion, comprising:

- costs attributable to moderate TBI ($3.7 billion) and severe TBI ($4.8 billion);
- financial costs ($3.7 billion) and burden of disease costs ($4.9 billion); and
- the greatest portions borne by individuals (64.9%), the State Government (19.1%) and Federal Government (11.2%).

The lifetime costs per incident case of TBI were estimated to be $2.5 million and $4.8 million for moderate TBI and severe TBI respectively, across Australia.

SCI

The total cost of **SCI** in Australia was estimated to be $2.0 billion, comprising:

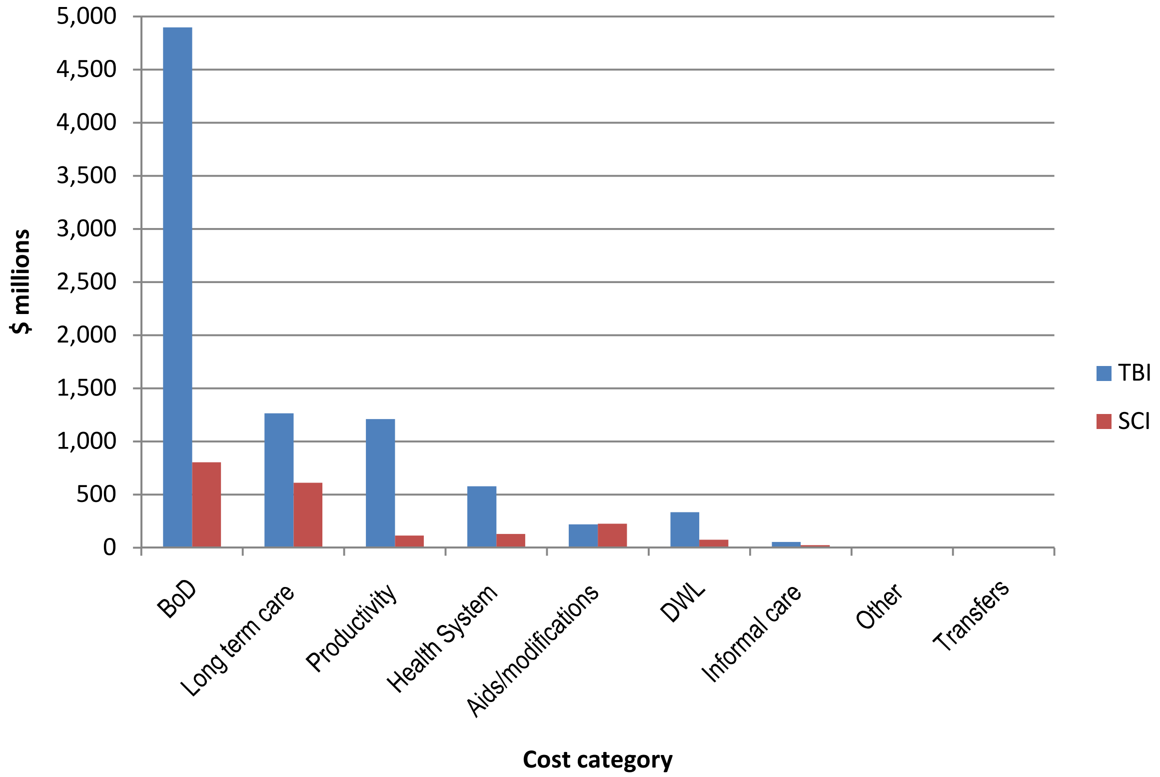
- costs attributable to paraplegia ($689.7 million) and quadriplegia ($1.3 billion);
- financial costs ($1.2 billion) and burden of disease costs ($803.2 million); and
- the greatest portions borne by the State Government (44.0%), individuals (40.5%) and the Federal Government (10.6%).

The lifetime cost per incident case of SCI was estimated to be $5.0 million per case of paraplegia and $9.5 million per case of quadriplegia, across Australia.

Summary

The dollar value of the loss of wellbeing for TBI was over five times the comparable figure for SCI. This is due to a higher mortality rate for TBI after injury leading to higher YLL. The dollar value of the loss of wellbeing was the highest of all cost categories for TBI and SCI, followed in both cases by long term care costs and productivity costs. Interestingly, despite much lower incidence for SCI, the total cost of aids and modifications were higher for SCI compared to TBI (Table 8-1, Table 8-2, Figure 8.1).

FIGURE 8.1: LIFETIME COST OF INCIDENT CASES OF TBI/SCI IN 2008 BY COST CATEGORY, AUSTRALIA, SORTED BY MAGNITUDE



Source: Access Economics calculations. The costs are the net present value of lifetime costs that result from incident cases in one year.

Sensitivity analysis

Based on alternative (upper limit) incidence estimates described in Appendix B, the total economic costs are estimated to be substantially higher as follows:

- TBI – 21.4 billion; and
- SCI – 5.7 billion.

> The total cost of TBI and SCI combined in Australia was estimated to be $10.5 billion.

TABLE 8-1: SUMMARY OF LIFETIME COSTS FOR INCIDENT CASES OF TBI AND SCI IN 2008– AUSTRALIA ($)

	Traumatic brain injury			Spinal cord injury			Grand total
	Moderate	Severe	Total	Paraplegia	Quadriplegia	Total	
Cost category ($ NPV million)							
BoD	2,206.6	2,691.9	4,898.5	320.7	482.5	803.2	5,701.7
Health System costs	269.1	308.0	577.1	52.5	76.5	129.0	706.1
Aids and modifications cost	59.7	158.5	218.2	113.2	113.6	226.8	445.0
Long term care costs	300.0	962.5	1,262.6	109.4	500.7	610.1	1,872.7
Productivity Costs	698.2	510.9	1,209.1	54.8	58.4	113.2	1,322.3
Carer Costs	25.1	28.5	53.5	9.1	14.6	23.8	77.3
Other costs	0.7	0.7	1.4	0.0	0.0	0.1	1.5
DWL	174.6	150.5	325.1	30.0	41.5	71.5	396.6
Transfers	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	3,734.0	4,811.5	8,545.5	689.7	1,287.9	1,977.6	10,523.1
Cost type ($ NPV million)							
Financial	1,527.4	2,119.5	3,647.0	369.0	805.4	1,174.5	4,821.4
BoD	2,206.6	2,691.9	4,898.5	320.7	482.5	803.2	5,701.7
Total	3,734.0	4,811.5	8,545.5	689.7	1,287.9	1,977.6	10,523.1
Per incident case ($ NPV million)							
Financial	1.0	2.1	1.6	2.7	5.9	4.3	
BoD	1.5	2.7	2.1	2.3	3.5	2.9	
Total	2.5	4.8	3.7	5.0	9.5	7.2	
Per incident case per year NPV $							
Financial	34,102	84,761	59,432	89,560	236,561	163,061	
BoD	49,265	107,652	78,458	77,834	141,700	109,767	
Total	83,367	192,413	137,890	167,394	378,262	272,828	

Source: Access Economics calculations. *Mean survival estimated as 30 years for moderate TBI and paraplegia and 25 years for severe TBI and quadriplegia. Calculations may not reconcile due to rounding. The costs are the net present value of lifetime costs that result from incident cases in one year.

Table 8-2: TBI/SCI costs by payer group – Australia ($) million

	Individuals	Family and Friends	Federal Government	State Government	Employers	Society/Other	Total
TBI							
Moderate TBI	2,561.7	-3.6	531.2	430.2	1.1	213.4	3,734.0
Severe TBI	2,987.3	-2.9	429.7	1,201.7	0.7	194.8	4,811.5
Total TBI	5,549.0	-6.4	960.9	1,631.9	1.8	408.2	8,545.5
% of total for payer	64.9%	-0.1%	11.2%	19.1%	0.0%	4.8%	100.0%
SCI							
Paraplegia	325.4	2.6	87.7	236.3	0.1	37.6	689.7
Quadriplegia	475.2	4.0	121.7	634.4	0.1	52.5	1,287.9
Total SCI	800.6	6.6	209.3	870.8	0.3	90.1	1,977.6
% of total for payer	40.5%	0.3%	10.6%	44.0%	0.0%	4.6%	100.0%

Source: Access Economics calculations. Calculations may not reconcile due to rounding.

8.2 COSTS FOR VICTORIA

TBI

The total cost of **TBI** in Victoria was estimated to be $2.2 billion, comprising:

- costs attributable to moderate TBI ($946.2 million) and severe TBI ($1.2 billion);
- financial costs ($942.1 million) and burden of disease costs ($1.2 billion); and
- the greatest portions of cost borne by individuals (66.8%), the State Government (19.2%) and Federal Government (9.7%).

The lifetime costs per incident case of TBI were estimated to be $2.6 million and $5.0 million for moderate TBI and severe TBI respectively in Victoria. Cost differed due to the higher proportion of compensable patients in Victoria.

SCI

The total cost of **SCI** in Victoria was estimated to be $575.8 million, comprising:

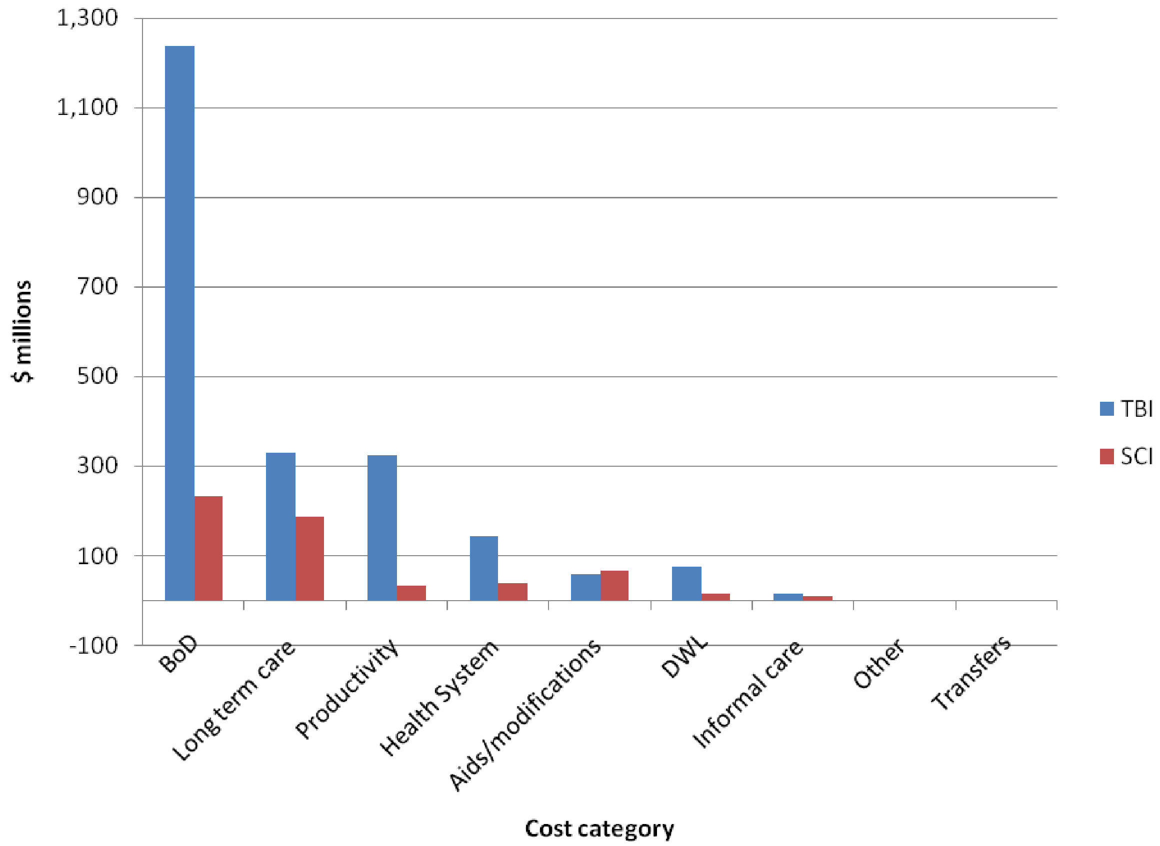
- costs attributable to paraplegia ($178.1 million) and quadriplegia ($397.7 million);
- financial costs ($343.1 million) and burden of disease costs ($232.7 million); and
- the greatest portions borne by the State Government (45.2%), individuals (44.3%) and the Federal Government (6.8%).

The lifetime costs per incident case of SCI were estimated to be $4.9 million and $7.6 million for paraplegia and quadriplegia respectively in Victoria.

Summary

The distribution of costs was the same as previously described for Australia (Figure 8.2, Table 8-3,Table 8-4).

FIGURE 8.2: LIFETIME COST OF INCIDENT CASES OF TBI/SCI IN 2008 BY COST CATEGORY, AUSTRALIA, SORTED BY MAGNITUDE



Source: Access Economics calculations. The costs are the net present value of lifetime costs that result from incident cases in one year.

The total cost of TBI and SCI combined in Victoria was estimated to be $2.8 billion.

Table 8-3: Summary of lifetime costs for incident cases of TBI and SCI in 2008– Victoria ($)

	Traumatic brain injury			Spinal cord injury			Grand total
	Moderate	Severe	Total	Paraplegia	Quadriplegia	Total	
Cost category ($ NPV million)							
BoD	558.5	678.4	1,236.8	82.1	150.6	232.7	1,469.5
Health System costs	66.7	76.1	142.8	13.5	24.7	38.3	181.1
Aids and modifications cost	15.6	41.4	57.0	30.4	36.5	66.9	123.9
Long term care costs	78.4	250.7	329.1	29.3	155.1	184.3	513.4
Productivity Costs	183.4	140.3	323.7	14.3	16.9	31.2	354.9
Carer Costs	6.6	7.5	14.1	2.4	4.8	7.2	21.3
Other costs	0.2	0.2	0.4	0.0	0.0	0.0	0.4
DWL	36.8	38.2	75.0	6.0	9.1	15.1	90.2
Transfers	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	946.2	1,232.7	2,178.9	178.1	397.7	575.8	2,754.6
Cost type ($ NPV million)							
Financial	387.7	554.4	942.1	96.0	247.1	343.1	1,285.2
BoD	558.5	678.4	1,236.8	82.1	150.6	232.7	1,469.5
Total	946.2	1,232.7	2,178.9	178.1	397.7	575.8	2,754.6
Per incident case ($ NPV million)							
Financial	1.0	2.2	1.6	2.7	4.8	3.7	
BoD	1.5	2.7	2.1	2.3	2.9	2.6	
Total	2.6	5.0	3.8	4.9	7.6	6.3	
Per incident case per year NPV $							
Financial	34,913	89,412	62,163	88,857	190,087	139,472	
BoD	50,287	109,412	79,850	76,045	115,808	95,927	
Total	85,200	198,824	142,012	164,902	305,895	235,399	

Source: Access Economics calculations. *Mean survival estimated as 30 years for moderate TBI and paraplegia and 25 years for severe TBI and quadriplegia. Calculations may not reconcile due to rounding. The costs are the net present value of lifetime costs that result from incident cases in one year.

TABLE 8-4: TBI/SCI COSTS BY PAYER GROUP – VICTORIA, ($) MILLION

	Individuals	Family and Friends	Federal Government	State Government	Employers	Society/Other	Total
TBI							
Moderate TBI	684.4	-1.9	107.6	109.5	0.3	46.3	946.2
Severe TBI	771.9	-2.0	103.9	309.6	0.3	49.1	1,232.7
Total TBI	1,456.3	-3.9	211.5	419.1	0.6	95.3	2,178.9
% of total for payer	66.8%	-0.2%	9.7%	19.2%	0.0%	4.4%	100.0%
SCI	91.6	0.6	15.2	62.8	0.0	7.9	178.1
Paraplegia	163.3	0.6	23.8	197.3	0.0	12.6	397.7
Quadriplegia	254.9	1.2	39.0	260.1	0.1	20.6	575.8
Total SCI	44.3%	0.2%	6.8%	45.2%	0.0%	3.6%	100.0%
% of total for payer	684.4	-1.9	107.6	109.5	0.3	46.3	946.2

Source: Access Economics calculations.

For a summary of data inputs utilised in the Victorian economic costing, please refer to Appendix A Table A5.

8.3 COMPARISON WITH OTHER CONDITIONS

This section compares the economic cost of TBI/SCI with other conditions i) with a similar epidemiology[27] (neurological conditions), ii) similar incidence (SCI only) and ii) similar causal mechanism (injury).

- **TBI**. The total economic cost of TBI (moderate and severe combined) appears to be much higher than all neurological conditions previously assessed by Access Economics including dementia, bipolar disorder, multiple sclerosis, muscular dystrophy and cerebral palsy. It also appears to be higher than the economic cost of workplace injuries which have a similar causal mechanism.
- **SCI**. The economic cost of SCI (paraplegia and quadriplegia combined) also appears to be high relative to neurological conditions previously assessed by Access Economics. It is also higher than similarly low incidence conditions such as ulcerative colitis and Crohn's disease.

However, reliable comparison is limited due to the following issues:

- Costing approaches include both incidence and prevalence-based which lead to different results (refer to 3.1).
- Costs relate to different source years (2002 – 2009).

The estimated cost per case per year is likely to be a more meaningful comparison and was estimated as follows:

- for prevalence-based costs – by dividing the economic costs by total prevalence for reference year; and
- for incidence based costs – by dividing economic costs by incidence for the reference year and mean survival (only relates to SCI / TBI).

The only cost category available for all conditions was the financial cost. Based on mean annual financial costs per patient:

- **TBI**. Costs for TBI were higher than all comparator conditions, except muscular dystrophy
- **SCI.** Costs for SCI were higher than all comparator conditions. The annual financial cost per case of quadriplegia was between 2 and 20 times higher than all other conditions (Table 8-5).

[27] TBI/SCI patients are typically injured at a young age (late adolescence and early adulthood) and are disabled for the remainder of their lives.

TABLE 8-5: ECONOMIC COST OF TBI/SCI COMPARED TO OTHER CONDITIONS

Condition	Year of study	Incidence (I) Prevalence (P) in Australia	Total cost ($)			Estimated cost per case per year ($)			Costing approach*	Neurological condition	Low incidence	Similar cause
			Total	Financial	BoD	Total	Financial*	BoD				
Quadriplegia	**2008**	**560 (I)**	**1.3bn**	**805.4mn**	**482.5mn**	**378,262**	**236,561**	**141,700**	**I**			
Muscular Dystrophy	2007	3,457 (P)	1.4bn	0.4bn	1bn	415,100	125,832	n/a	P	✓		
Paraplegia	**2008**	**359 (I)**	**689.7mn**	**369.0mn**	**320.7mn**	**167,394**	**89,560**	**77,834**	**I**			
Severe TBI	**2008**	**3,718 (I)**	**4.8bn**	**2.1bn**	**2.6bn**	**192,413**	**84,761**	**107,652**	**I**			
Cerebral Palsy	2007	33,797 (P)	3.9bn	1.5bn	2.4bn	115,099	43,431	n/a		✓		
Dementia	2002	162,000 (P)	6.6bn	n/a	n/a	40,741	40,741	n/a	P	✓		
Multiple Sclerosis	2005	16,081 (P)	1.94bn	0.6bn	1.34bn	120,683	37,333	n/a	P	✓		
Moderate TBI	**2008**	**1,762 (I)**	**4.7n**	**1.5bn**	**2.2bn**	**83,367**	**34,102**	**49,265**	**I**			
Bipolar disorder	2003	99,099 (P)	1.6bn	n/a	n/a	16,145	16,145	n/a	P	✓		
Crohn's Disease	2005	28,000 (P)	n/a	$239m	n/a	n/a	8,536	n/a	P		✓	
Ulcerative Colitis	2005	33,000 (P)	n/a	$258m	n/a	n/a	7,818	n/a	P		✓	
Workplace Injury	2000	1,618 per 100,000 resident (2000)	28.9bn	n/a	n/a	92,600	n/a	n/a	I			✓

Table note: *Sorted by estimated financial cost per case per year. **Estimated cost per case per year for combined severity calculated as average across two severities for TBI/SCI. bn: billion, mn: million.

9. POTENTIAL IMPACT OF IMPROVED MANAGEMENT STRATEGIES

9.1 GENERAL METHODOLOGY

This chapter evaluates the cost effectiveness of two interventions funded by the VNI/TAC, namely:

- the use of saline and albumin for fluid resuscitation in patients with TBI; and
- the use of continuous positive airway pressure (CPAP) in patients with quadriplegia and obstructive sleep apnoea/hypopnoea (OSA).

This list of interventions was prepared in conjunction with the VNI steering group. Access Economics acknowledges with appreciation the effort that the group invested to assist with identifying appropriate interventions and refining the clinical treatment pathways.

The results for each scenario are summarised in the following two sub-sections.

- Section 9.3: the cost effectiveness of the use of saline versus albumin for fluid resuscitation in patients with TBI, based on the results of a clinical trial which found that use of saline was associated with lower mortality rates than albumin.
- Section 9.4: the cost effectiveness of the use of CPAP versus no CPAP, with the main benefit of an improvement in the quality of sleep for people with quadriplegia.

Each section commences by briefly describing the background for the intervention. Literature and data investigated are then reported in relation to the probability of various outcomes, and cost parameters are also presented. In each case the intervention is compared to a counterfactual, including no program implemented or standard care, for example.

9.2 PARTICULAR METHODOLOGICAL ASPECTS

The interventions are evaluated using both incremental cost effectiveness analysis and cost benefit analysis (CBA).

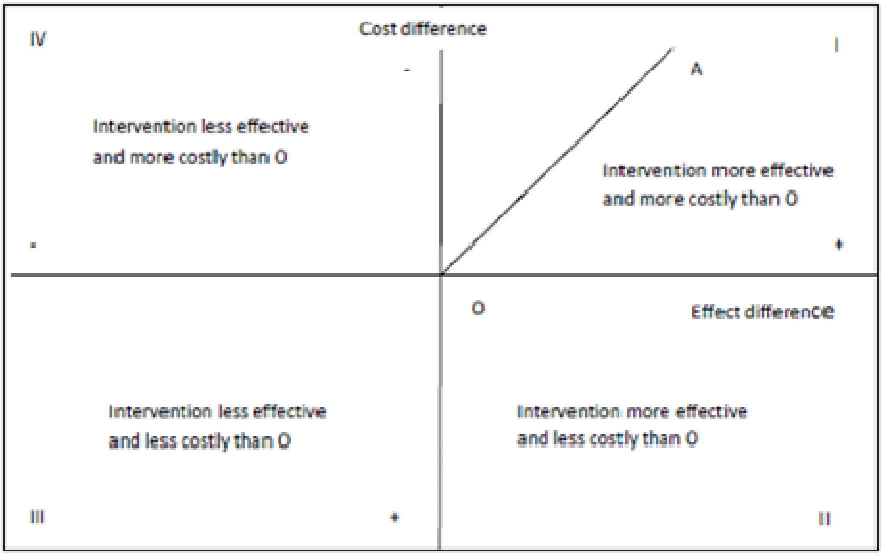
An incremental cost effectiveness ratio (ICER) is calculated for each intervention strategy relative to its comparator in terms of incremental costs per DALY averted.

Figure 9.1 presents the cost effectiveness plane (Drummond, 2005). The horizontal axis in Figure 9.1 represents the difference in effect between the intervention of interest (A) and the relevant alternative or comparator (O) while the vertical axis represents the difference in cost. The slope of the line OA gives the cost effectiveness ratio.

- If financial benefits outweigh financial costs, and there is no change in health outcomes, an intervention is described as **cost-saving**.
- If the intervention saves costs and gains more QALYs (or averts more DALYs) relative to its comparator, it is described as **dominant** (and its comparator is **dominated**).
- If an intervention is more expensive than its comparator but gains more QALYs (or averts more DALYs), cost effectiveness benchmarks or other tools are needed to decide whether or not to pursue the intervention.

- If an intervention is less expensive but also associated with fewer QALYs than the comparator, benchmarks or tools are also required.

FIGURE 9.1: THE COST-EFFECTIVENESS PLANE



Source: Drummond (2005)

Cost benefit analysis, on the other hand, determines the net present value (NPV) of the costs and benefits of a particular intervention program. If the net difference is positive then the intervention should be implemented. Cost benefit analysis also has an internal benchmark – the 'breakeven point' (i.e., anything above this 'zero' benchmark is a net benefit).

A variety of benchmarks may be used to determine public financing thresholds (Access Economics, 2008) such as:

- gross domestic product (GDP) per capita i.e. around $52,000 in 2008-09 – in line with the WHO guidelines that interventions whose cost effectiveness is between one and three times GDP per capita per QALY gained (or DALY averted) are cost effective and those less than GDP per capita per QALY gained (or DALY averted) are very cost effective[28],
- $60,000 – in line with the Department of Health and Ageing - DoHA (2003); or
- the VSLY of $151,000 in 2007[29] which when indexed to 2008 using CPI is $157,795[30].

Both ICERs and CBA involve the estimation of costs and benefits over a number of years, with future benefits and costs discounted to the present using the discount rate described in Section 3.2. For all intervention scenarios, the time period over which they were evaluated was ten years — a common timeframe for analysis of health programs (see Access Economics, 2008, Appendix C).

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28 http://www.who.int/choice/costs/CER_levels/en/index.html Average GDP per capita for the Western Pacific region including Australia is shown as US$30,708 with three times that shown as US$92,123 in the year 2005.

29 http://www.finance.gov.au/obpr/docs/ValuingStatisticalLife.pdf

30 Year ended % change June 2007 to June 2008 http://www.rba.gov.au/Statistics/measures_of_cpi.html

9.3 SALINE VS ALBUMIN FOR FLUID RESUSCITATION IN PATIENTS WITH TBI

9.3.1 BACKGROUND

In the clinical world, there have been debates regarding whether the selection of fluid resuscitation (saline or albumin) for patients admitted to intensive care units (ICUs) affects mortality outcomes (SAFE study investigators, 2004). A double blind, randomised controlled trial conducted by the SAFE study investigators between 2001 and 2003 in Australia and New Zealand suggested that the use of either human albumin (4%) or normal saline (9% sodium chloride) did not induce any significant difference in outcomes for patients admitted to ICUs 28 days after randomisation. However, their findings also suggested that there was evidence of a heterogeneous effect among those with and without a diagnosis of trauma (SAFE study investigators, 2007). As a result, a post hoc follow-up study was conducted on patients with TBI who were enrolled in the randomised trial (SAFE study investigators, 2007). The authors concluded that intravascular fluid resuscitation for those with severe TBI in the ICU with albumin was associated with significantly higher mortality rates than resuscitation with saline. The difference was due to a higher mortality rate within 28 days of randomisation in the subgroup of patients with severe TBI (GCS score: 3-8) who were treated with albumin (SAFE study investigators, 2007). The purpose of this section is to evaluate the cost effectiveness of the use of saline relative to the use albumin on severe TBI patients using information from the SAFE study (SAFE study investigators, 2007).

Specifically, 460 TBI patients (i.e. with history of trauma, evidence of head trauma on a computed tomographic scan and a score of ≤ 13 on the Glasgow Coma Scale (GCS)), were randomised to either albumin (231 patients) or saline (229 patients) (SAFE study investigators, 2007). The subgroup of patients with a GCS of three to eight were classified as having severe brain injury while those with a score of nine to 12 were classified as having moderate brain injury. There were a total of 318 and 98 patients in the severe and moderate TBI groups respectively. Out of 318 (98) patients in the severe (moderate) category, 160 (53) patients were in the albumin group while there were 158 (44) patients in the saline group. Demographic characteristics and indexes of severity of brain injury were similar at baseline.

At 24 months, among patients with severe brain injury, 61 of 146 patients in the albumin group (41.8%) died, as compared with 32 of 144 in the saline group (22.2%) (relative risk, 1.88; 95% CI, 1.31–2.70; P<0.001); among patients with moderate brain injury, death occurred in 8 of 50 patients in the albumin group (16.0%) and 8 of 37 in the saline group (21.6%) (relative risk, 0.74; 95% CI, 0.31–1.79; P = 0.50).

9.3.2 COSTS OF SALINE AND ALBUMIN

A bottom up costing method was adopted for estimating the costs of intravascular fluid resuscitation in the ICU. The following information was required:

- full time equivalent staffing needs and associated pay;
- dosages administered;
- unit cost of normal saline and 4% albumin; and
- infrastructure required.

Expert guidance revealed that the process of administering the fluid was essentially similar between saline and albumin so the only difference in costs reflected any difference in the cost of using saline as opposed to albumin (expert clinical guidance, Professor and Deputy Director, ICU Jamie Cooper, Monash University and Alfred Hospital Melbourne, personal communication, 2 April 2009). The dosages were obtained from the SAFE study investigators (2007) article and are summarised in Table 9-1.

TABLE 9-1: AMOUNT OF SALINE AND ALBUMIN ADMINISTERED

	Albumin group		Saline group	
Period	**No. of patients**	**Amount (ml)**	**No. of patients**	**Amount (ml)**
Day 1	231	1,267.0	229	1,766.6
Day 2	223	686.8	223	911.9
Day 3	207	329.7	196	435.2
Day 4	186	197.6	178	201.7
Total		**2,481.1**		**3,315.4**

Source: SAFE study investigators (2007)

The cost of saline in Australia is approximately $1/litre (expert clinical guidance, Professor and Deputy Director, ICU Jamie Cooper, Monash University and Alfred Hospital Melbourne, personal communication, 2 April 2009). In the absence of published costs for albumin in Australia, global price data were sourced from the Center of Medicare and Medicaid Services (CMS) in the United States. Table 9-2 presents the price list for saline and albumin obtained from the Medicare Part B Drug Average Sale Price (ASP) where the prices were three month lagged average manufacturing selling prices plus 6% and were used for Medicare Part B reimbursement. Essentially, the payment amounts are 106% of the average sales price calculated from data submitted by drug manufacturers.

TABLE 9-2: SALINE AND ALBUMIN PRICES BASED ON CMS, US

Code	Description	Code dosage	Payment limit (USD)
J7030	Normal saline solution infus	1000cc	$1.084
J7040	Normal saline solution infus	500ml	$0.542
J7042	5% dextrose/normal saline	500ml	$0.305
J7050	Normal saline solution infus	250cc	$0.271
P9041	Albumin (human), 5%	50ml	$28.149
P9045	Albumin (human), 5%	250ml	$56.326
P9046	Albumin (human), 25%	20ml	$26.353
P9047	Albumin (human), 25%	50ml	$52.735

Note: Payment allowance limits for Medicare Part B Drugs, effective April 1, 2009 through June 30, 2009.

Source: Center of Medicare and Medicaid (CMS), United States (http://www.cms.hhs.gov/McrPartBDrugAvgSalesPrice/01a1_2009aspfiles.asp#TopOfPage).

Based on US costs and prices in Table 9-2, the price of a normal saline fluid was approximately **$1.60/litre** in 2008 Australian dollars (very similar to the rough estimate given by Professor Jamie Cooper)[31].

The price of 4% albumin fluid was not listed by the CMS, only the price of 5% albumin was available. The price of 5% albumin in a 250 ml bottle was used in this report (see Table 9-2). This converts to approximately **$332.11/litre** in 2008 Australian dollars[32].

[31] Converted using 2008 Purchasing Power Parity (PPP) obtained from the Organisation for Economic Co-operation and Development (OECD) website http://stats.oecd.org/wbos/Index.aspx?datasetcode=SNA_TABLE4, accessed 14 April 2009.

[32] Converted as per saline.

Applying the converted CMS prices of saline and albumin to the dosages presented in Table 9-1, the total cost for saline and albumin treatment for each patient was approximately **$5.30** and **$824.00** respectively.

9.3.3 OUTCOMES OF SALINE AND ALBUMIN

The main purpose of the clinical trial was to test the effectiveness of saline and albumin for fluid resuscitation of TBI patients in terms of mortality rates (or survival rates). The findings of the SAFE study investigators (2007) indicated that fluid resuscitation with albumin was associated with significantly higher mortality rates for those with severe TBI than resuscitation with saline. The results are presented in Table 9-3.

TABLE 9-3: OUTCOMES OF CLINICAL TRIAL

Outcome	Albumin group	Saline group	Relative risk (95% CI)
Patients with a GCS score of 3-8: Severe TBI			
Deaths – no./total no. (%)			
Within 28 days	55/160 (34.4)	30/158 (18.9)	1.83 (1.23-2.71)
Within 6 mo	60/154 (38.9)	32/149 (21.5)	1.81 (1.26-2.61)
Within 12 mo	61/153 (39.9)	32/149 (21.5)	1.86 (1.29-2.67)
Within 24 mo	61/146 (41.8)	32/144 (22.2)	1.88 (1.31-2.70)
Survivors at 24 mo	51/78 (65.4)	77/108 (71.3)	0.92 (0.75-1.12)

Source: SAFE study investigators (2007).

For the purpose of conducting CEA, the mortality rates for albumin and saline within 12 months were utilised. The difference in mortality rate between albumin and saline is 18.4%. This was used to estimate the difference in gains and costs such as productivity gained from avoided premature deaths associated with the use of saline and albumin. Note that the CEA was only conducted for patients with severe TBI at the Australian level based on the incidence numbers estimated in earlier chapter. This analysis assumed that all incident cases of severe TBI received fluid resuscitation with saline.

9.3.4 CEA RESULTS

With a lower mortality rate compared to albumin, the use of saline as a resuscitated fluid would save costs such as productivity losses and burden of diseases due to premature death, although costs of long term care for survivors would be incurred.

Hence, based on the economic modelling, the total estimated DALYs averted are 17,915 and the total cost saved is $38,387. Because clinical treatment using saline is associated with improved health outcomes and saved costs, it is considered dominant, that is the use of saline dominated the use of albumin. The results are summarised in Table 9-4. The dominant finding remains the same if the proportion of all severe TBI cases administered saline is reduced to 50% of all incident cases. However, the cost savings and benefit are halved.

TABLE 9-4: BASELINE RESULTS OF COST EFFECTIVENESS ANALYSIS OF ALBUMIN AND SALINE

Discount rate	3%
Benefit = NPV of avoided cost of mortality due to use of saline ($ million)	$760.0 million
Cost = NPV of additional cost associated with patients surviving ($ million)	$72.2 million
Net Benefit	$687.7 million
Benefit/cost ratio	10.52
DALYs averted	17,915
ICERs – cost/DALYs	Dominant

Note: Calculations may not reconcile due to rounding.

Source: Access Economics calculations.

Sensitivity tests were conducted using a discount rate of 7%, and using 6 and 24 month mortality rates instead of 12 month mortality rates.

9.3.5 SENSITIVITY ANALYSIS

Table 9-5 presents the results from a series of sensitivity analysis. Overall, the outcome remained unchanged, i.e. saline treatment remained dominant.

TABLE 9-5: SENSITIVITY ANALYSIS FOR ALBUMIN AND SALINE

	Discount rate of 7%	6 month mortality rate	24 month mortality rate
Benefit = NPV of avoided cost of mortality due to the use of saline ($ million)	$659.2 million	$718.6 million	$809.5 million
Cost = NPV of additional cost associated with patients surviving ($ million)	$65.5 million	$68.3 million	$76.9 million
Net Benefit	$593.7 million	$650.3 million	$732.6 million
Benefit/cost ratio	10.06	10.52	10.52
DALYs averted	15,541	16,941	19,083
ICERs – cost/DALYs	Dominant	Dominant	Dominant

Note: Calculations may not reconcile due to rounding. Source: Access Economics calculations.

9.4 CPAP TREATMENT ON PATIENTS WITH QUADRIPLEGIA AND SLEEP APNOEA

9.4.1 BACKGROUND

Most patients with quadriplegia have difficulty sleeping which affects their daily functioning, quality of life and recovery from injury. Based on existing literature, the prevalence of disordered breathing during sleep among individuals with quadriplegia ranged from 27% to 62% (Douglas McEvoy et al, 1995; Burns et al, 2000; Stockhammer et al, 2002; Berlowitz et al, 2005; Leduc et al, 2007). This was many times more than the prevalence in the general population, which averaged approximately 4% (Access Economics, 2004) using obstructive sleep apnoea (OSA) as a proxy for 'disordered breathing', discussed below.

The most predominant form of sleep and breathing disorder among individuals with quadriplegia is OSA (Berlowitz et al, 2005). OSA is characterised by sleep-related intermittent upper airway obstruction, which may be associated with episodes of oxygen desaturations and sleep fragmentation. In OSA syndrome this is combined with symptoms such as snoring, excessive daytime sleepiness and cardiovascular sequelae (Klefbeck et al, 1998). The Apnea-Hypopnea Index (AHI), defined as the number of scored respiratory events per hour of sleep, was used to measure the existence and extent of OSA although definitions of mild, moderate and severe OSA can differ across studies (Klefbeck et al, 1998; Mar et al, 2003; Berlowitz et al, 2005; Ayas et al, 2006).

Based on different levels of AHI cutoffs, the incidence of sleep disorders found by Berlowitz et al (2005) using an Australian sample was most relevant to this report and is presented in Table 9-6. Their findings were based on a sample of 30 new patients who were seen with a cervical spinal cord injury (i.e. quadriplegia) at the Victorian Spinal Cord Service located at Austin Health, Australia.

As shown in Table 9-6, the proportion of patients with scores beyond any of the clinical cutoffs in Australia tended towards the upper end of the prevalence rate found in the literature.

TABLE 9-6: AVERAGE AHI SCORES AND PROPORTION OF PATIENTS WITH SCORES BEYOND CLINICAL CUTOFFS AT EACH ASSESSMENT TIME (*WEEKS POST INJURY)

Variables	2*	4*	13*	26*	52*
Average AHI scores	35.6	21.5	28.4	25.9	26.7
AHI>5 (%)	90.0	81.0	91.3	84.2	84.6
AHI>10 (%)	60.0	61.9	82.6	68.4	61.5
AHI>15 (%)	50.0	47.6	65.2	63.2	53.9
AHI>40 (%)	17.9	32.5	31.6	10.9	17.0

Source: Berlowitz et al (2005).

For individuals who were diagnosed with OSA, the most common type of treatment is the use of continuous positive airway pressure (CPAP) therapy. Positively pressurised air is supplied using CPAP through a nasal mask worn at night time. This lessens the collapse of the upper airway during inspiration, thereby reducing the frequency and severity of apnoeas (Burns et al, 2005).

Engleman et al (1995) and NHMRC (2000) suggest that CPAP therapy has a positive effect on patients with sleep disorders in the short to intermediate term. Outcome measures include a reduction in AHI and the Epworth 'sleepiness scale' (ESS) – a questionnaire that tests the likelihood of falling asleep in a variety of common situations. Long term effects such as lower mortality rates for cardiovascular diseases were also found (Doherty et al, 2005).

While there are many studies examining the *effectiveness* of CPAP, a literature review revealed no CEAs conducted, especially for patients with quadriplegia. Therefore, the aim of this section was to conduct a CEA on the use of CPAP therapy versus no CPAP therapy for patients with quadriplegia and with OSA.

9.4.2 COST OF CPAP TREATMENT

The treatment of OSA using CPAP is generally a long term process. For instance, it may take five years or more and its standard treatment protocol includes the following:

- two overnight sleep studies (one at start of CPAP treatment, one routine follow-up at 18 months;
- first follow-up consultation with a physician;
- five annual follow-up consultations;
- minor attendances by physicians;
- minor attendances by technicians;
- initial rental of appliances for three months;
- purchase of a CPAP machine (standard model); and
- minor apparatus replacement.

According to the 2000 National Health and Medical Research Council (NHMRC) report on the cost effectiveness of CPAP on OSA in adults, the treatment costs for a five year treatment could range from $2,869 to $4,548 with a median estimate of A$3,563 (in 1998 prices). The median cost is chosen as the base case for the CEA in this report and prices are inflated using the health price index, i.e. $4,875 (AIHW, 2008). The minimum and maximum treatment costs of $3,925 and $6,222 (inflated to 2008 prices) indicated in NHMRC report (2000) are used later in sensitivity testing.

9.4.3 Efficacy of CPAP treatment

While there were many research articles evaluating the effectiveness of CPAP treatment, many only focused on the immediate results. For instance, many articles reported a positive effect from CPAP treatment by a reduction in AHI and ESS indices. While a reduction in these indices indicates a positive outcome in terms of quality of sleep, the impact of such reductions for people with quadriplegia in terms of other long term health outcomes – such as cardiovascular diseases and diabetes – is less well documented (NHMRC, 2000).

One article by Doherty et al (2005) conducted a long-term follow up study of 168 patients with OSA who had been receiving CPAP therapy for at least five years. They compared the cardiovascular diseases (CVD) outcomes of those patients who were intolerant of CPAP (untreated group, 61 patients) with those continuing CPAP therapy (treated group, 107 patients). They found that the mortality rate of the untreated group was higher than that of treated group, a difference of 12.9%. This result was statistically significant at the 1% level.

To conduct a CEA, a conservative approach was taken in the calculation of the value of the benefit of CPAP treatment. According to Hillman et al (2004), the average direct health costs of sleep disturbances in 2004 was $120.57, inflated to $164.95 in 2008 prices using health price inflation (AIHW, 2008). This estimate was independent of comorbidities.

The cost of premature death (in terms of productivity loss) due to CVD was also included in this CEA analysis to represent the difference in mortality rates among those who complied with the CPAP treatment and those who did not. The compliance rate for CPAP treatment among patients with quadriplegia was approximately 63% compared to 68% for non-SCI patients (Burns et al, 2005) and the average incidence rate of CVD for the Australian population was approximately 0.44% (Begg et al, 2007). Cost estimation was in accordance with Access Economics (2005).

Other comorbidity costs such as those motor vehicles accidents and work related accidents that were related to non-SCI patients with OSA were excluded (Access Economics, 2004). This was because patients with quadriplegia were unlikely to incur further costs due to driving or work accidents given the severity and impacts of their existing injuries. Thus it is reasonable to assume that these costs do not apply.

9.4.4 CEA RESULTS

Taking into consideration the compliance rate of CPAP treatment, the baseline results are presented in Table 9-7 with a discount rate of 3% and a cost of CPAP treatment of $4,874.65. The number of sleep disorder related DALYs avoided was 287 (Access Economics, 2004). Overall, the cost per DALY was approximately $16,037 - less than $60,000 indicated by DoHA (2003). Hence, CPAP treatment was considered cost effective. Note that CEA was only conducted at the Australian level for patients with quadriplegia based on the incidence numbers estimated in earlier chapters.

TABLE 9-7: BASELINE RESULTS OF COST EFFECTIVENESS ANALYSIS OF CPAP TREATMENT

Discount rate	3%
Benefit = NPV of avoided cost of sleep disorders and mortality due to CVD/chronic disease ($)	$86,998
Cost = NPV of additional cost associated with patients surviving ($)	$1,118,795
Net cost	$1,031,797
Benefit/cost ratio	0.078
DALYs averted	64
ICERs – cost/DALYs	$16,037

Source: Access Economics calculations.

Sensitivity analysis was conducted using a 7% discount rate, and the minimum and maximum CPAP treatment costs reported in NHMRC (2000).

9.4.5 SENSITIVITY ANALYSIS

The results from various sensitivity analyses are presented in Table 9-8. The conclusion remained unchanged that is CPAP treatment is a cost effective treatment.

TABLE 9-8: SENSITIVITY ANALYSIS OF CPAP TREATMENT

	Discount rate of 7%	Minimum treatment cost ($3,925)	Maximum treatment cost ($6,222)
Benefit = NPV of avoided cost of mortality due to CVD/chronic disease ($)	$74,866	$86,998	$86,998
Cost = NPV of additional cost associated with patients surviving ($)	$962,775	$900,876	$1,428,088
Net cost	$887,090	$813,878	$1,341,090
Benefit/cost ratio	0.078	0.097	0.061
DALYs averted	55	64	64
ICERs – cost/DALYs	$16,037	$12,650	$20,844

Source: Access Economics calculations.

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Data provided

Australasian Rehabilitation Outcomes Centre. The AROC provided data on funding sources for TBI/SCI patients and support required pre and post injury for the year 2008.

Centrelink provided the number of Australians with TBI who received the Disability Support Pension for Qtr 1 2009.

Department of Human Services (Victoria) – Metropolitan Health & Aged Care Services Division. Data were provided on the frequency, mean length and cost of acute hospital separations stratified according to funding type for TBI patients for the year 2007-08.

Department of Human Services (Victoria) – Disability support. Data were provided on carers, independence in activities of daily living, disability services and employment for Victorians with ABI for the year 2007-08.

New South Wales Spinal Cord Injury Service. Data were provided on the incidence of SCI in NSW and healthcare utilisation for SCI patients for year 2007-08.

Queensland Trauma Registry. Data were provided on the incidence of TBI/SCI and healthcare utilisation of TBI/SCI patients in Queensland for year 2007.

Transport Accident Commission. The TAC provided detailed data on the costs for healthcare, long term care, equipment and modifications, administration and compensation to families for TBI and SCI patients in Victoria for pay years 2004-2008.

Victorian State Trauma Registry. Upon request, the VSTR provided incidence, mortality and health outcome data relating to TBI and SCI for Victoria for year 2007-08.

APPENDIX A

Table A1: Studies reporting mortality risk after TBI

Study	Sample Size	Location	Profile	Observation period	Results
Baguley et al 2008*	69	Australia	Functionally dependent adults with severe TBI	1.7-18.8 years, mean 10.5 years post injury	Standardized mortality rate of 13.2 over 10 years
Myburgh et al 2008*	635	Australia and New Zealand	Adult TBI	6 months	12 months mortality rate 26.9% for mild, moderate and severe and 35.1% for severe
Flaada et al 2006*	1433	USA	89% mild TBI, 11% moderate/severe TBI	10 years	Mortality for moderate/severe cases nearly 40 times that for mild cases, independent of age
Brown et al 2004	164	USA	Moderate and severe TBI	15 years, mean 7.4 years	Est 30-day case fatality rate of 29%; no difference in deaths at six months between observed/general population; risk ratio (95% CI) of 5.29 (4.11-6.71) for observed mortality over the full period of follow-up
Strauss et al 1998	946	USA	Children and adolescents aged 5-21 years with moderate and severe TBI	9 years	High-functioning persons - life expectancy 3-5 years shorter than for the general population. Those without mobility 6 months after injury - life expectancy of only 15 years
Ratcliff et al 2005	642	USA	Moderate to severe TBI	24 months	Two fold risk for increased mortality
Cameron et al 2008	1290	Canada	TBI	10 years	Mortality rate ratio 1.48 (excluding mortality in first 60 days, after adjusting for demographic differences and pre-existing health status)

*Indicates studies used to inform this analysis

TABLE A2: STUDIES REPORTING MORTALITY RISK AFTER SCI

Study	Sample Size	Location	Profile	Observation period	Results
Yeo et al 1998*	1453	Australia	SCI	40 years	Mean life expectancy 70% of normal population for tetraplegia and 84% for paraplegia
DeVivo et al 1987	5131	USA	SCI surviving 24 hours post injury	7 years	Seven year survival 86.7%. Probability of dying greatest in 1st year post injury. Excluding 1st year mortality, survival was 90.6%
Saunders et al 2009	4353	USA	Traumatic SCI	17 years	Mortality rate of 27.4/1million population
Strauss et al 2000	19226	USA	SCI two years post injury	23 years	Life expectancy for SCI at 30 years old (general population 45.51 years): 26.78 years for C1-C4 ABC 31.55 years for C5-C8 ABC 36.32 years paraplegic ABC 40.11 years for D
Frankel et al 1998	3179	UK	SCI one year post injury	47 years	Life expectancy for SCI at 30 years old (male) (general population 44.36 years): 26.34 years for tetraplegia ABC 33.72 years for paraplegia ABC 34.33 years for D
Strauss et al 2006	30822	USA	SCI one day post injury	31 years	40% decline in mortality during first 2 years after injury over 30 years. No statistically significant decline in mortality in the post–2-year period
McColl et al 1997	606	Canada	SCI in 25-34 year olds	45 years	Median survival 38 years post injury with 43% surviving at least 40 years.

*Indicates studies used to inform this analysis

TABLE A3: LEVEL OF SPINAL CORD INJURY AND ASSOCIATED SCI SEVERITY

	Type of cord lesion	Per cent	Associated SCI severity
a	Cervical	47.7	Quadriplegia
b	Thoracic	18.1	Paraplegia
c	Lumbar	12.7	Paraplegia
d	No code	23.8	
e	With code	78.8%	
a/e	Quadriplegia	60.9%	
(b+c)/e	Paraplegia	39.1%	

Source: Henley (2009).

TABLE A4: CASES OF TBI REPORTED BY STATE TRAUMA REGISTERS

	TBI		SCI	
	Moderate	Severe	Paraplegia	Quadriplegia
Victoria	11%	20%	41%	59%
NSW			43%	57%
Queensland	7%	21%	56%	44%
	9%	21%	47%	53%

Source: VSTR (2009), QTR (2009), NSW SCIR (2009). Notes: QTR code cases based on the AIS coding system which makes a distinction for the cervical spine as an area, and within that, makes a distinction between C-4 and above and C-3 and below. It was assumed that anything in the cervical spine area is quadraplegia.

TABLE A5: DATA SOURCED FOR AUSTRALIAN AND VICTORIAN ANALYSIS

Report section and data required	Source for Australian analysis	Source for Victoria analysis
Distribution of payer	AIHW for Aus	AIHW for Vic
Population distribution / mortality	Aus	Utilise Vic data.
Incidence	Aus	Utilise Vic data.
Mortality rates	Aus	*
Direct health system costs	Vic (TAC) (weighted average for compensable / non compensable)	Utilise Vic data (to capture higher proportion of compensable patients)
Other financial costs	Aus	*
Productivity losses Workforce participation for TBI & SCI.		
Sick days for TBI & SCI.	Aus	*
Carers time for TBI & SCI.	Aus/ International	*
Aids and modifications.	Vic (TAC) (weighted average for compensable / non compensable)	Utilise Vic data (to capture higher proportion of compensable patients)
Long term care	Vic (TAC) (weighted average for compensable / non compensable)	Utilise Vic data (to capture higher proportion of compensable patients)
Funeral costs	Aus	*
Deadweight losses	Aus	*
Burden of disease.	International	*
Years of life lost due to premature death (YLL) (based on RR mortality)		

Table note: * same source as Australian analysis.

APPENDIX B

Alternative methods for incidence estimates

TBI

Incidence data available. The National Injury Surveillance Unit (NISU) at Flinders University is the AIHW collaborating agency tasked with surveillance at the national level in the area of injury. NISU have not previously published incidence data for TBI due to a range of data limitations and methodological issues[33]. However, NISU published data on the number of hospital separations due to TBI in 2004-05 based on data retrieved from the AIHW National Hospital Morbidity Database (NHMD) (Helps et al, 2008). This study reported 22,710 TBI separations based on the following inclusion criteria:

- **definition of TBI**: all ICD-10 S06 codes (refer to TABLE B1);
- **cause of injury**: cases restricted to 'traumatic' causes;
- **diagnosis**: cases included TBI as principal or additional diagnosis; and
- **time period**: 2004-05.

TABLE B1: TBI SEPARATIONS BY GENDER, 2004-05

Male	Female	Total
15,611	7,099	22,710

Source: Helps et al (2008). Note: 62.5% (n=14,190) recorded an S06 code as the principal diagnosis.

TABLE B2: ICD-10 CODES UTILISED TO RETRIEVE TBI SEPARATIONS FROM THE NHMD

ICD–10 code	Description
S06.0	Concussion
S06.1	Traumatic cerebral oedema
S06.2	Diffuse brain injury
S06.3	Focal brain injury
S06.4	Epidural haemorrhage
S06.5	Traumatic subdural haemorrhage
S06.6	Traumatic subarachnoid haemorrhage
S06.7	Intracranial injury with prolonged coma
S06.8	Other intracranial injuries
S06.9	Intracranial injury, unspecified

Source: Helps et al (2008).

Incidence estimates. In the absence of national incidence data, this analysis sought to estimate the incidence of moderate and severe TBI in Australia for the year 2008 for cost modelling purposes. The estimation was based on a series of adjustments to the NISU reported number of hospital separations due to TBI in 2004-05 summarised below and described in detail in TABLE B3. The adjustments:

[33] Source: personal consultation with NISU, 16/4/9

- applied severity classifications (mild, moderate and severe) and removed separations attributable to 'mild' TBI (mild TBI is out of scope for this analysis);
- removed 'subsequent' separations (separations after the first admission) to estimate 'incident' separations;
- applied an age distribution; and
- increased incidence consistent with population growth between 2005 to 2008.

TABLE B3: APPROACH TO ESTIMATE INCIDENCE FOR THIS ANALYSIS - TBI

Issue / context	Adjustment	Methodology for adjustment or impact if no adjustment
Helps et al (2008) did not report severity classifications for TBI cases or report Glasgow coma scale scores or any other physiological measure which would enable the estimation of TBI severity.	Applied severity classifications (mild, moderate and severe) and removed separations attributable to 'mild' TBI (mild TBI is out of scope for this analysis)	For estimation purposes, we assumed that the proportion of separations reported by Helps et al (2008) in each TBI severity category (mild, moderate and severe) was the same as the mean calculated from the state trauma registries of Victoria (VSTR, 2009) and Queensland (QTR, 2009), specifically: mild 70%, moderate 9% and severe 21%, see TABLE B4. These severity classifications were applied to the TBI separations reported by Help et al (2008). The cases estimated to be 'mild' (n=15,954) were removed from the subsequent analysis.
Individuals who are hospitalised more than once will be counted twice or more ('upside' risk). Helps et al (2008) could not identify multiple records for individual cases. Therefore, readmissions for the original injury could not be excluded.	Removed 'subsequent' separations (separations after the first admission) to estimate 'incident' separations.	The mean number of acute episodes of care for people with moderate/severe TBI (combined) was reported as 1.25 by VSTR (2009) for 2007-08. The number of separations reported by Helps et al (2008) (estimated as either moderate or severe) was divided by 1.25 to estimate the number of 'first admissions', a proxy for incident cases.
To enable the estimation of the distribution of TBI costs by age groups.	Applied age distribution	Separations data for the ICD-10 codes (all S06) and year (2004-05) utilised by Helps et al (2008) were retrieved from the AIHW NHMD disaggregated by age. This age distribution was applied to the estimated number of incident cases of moderate and severe TBI.
Analysis is for reference year 2008, however source data are from 2005.	Increased incidence consistent with population growth between 2005 to 2008	Age and gender specific population incidence rates were estimated for the year 2005. Age and gender specific incidence rates were then applied to the 2008 Australian population. Population data were sourced from the Access Economics demographic model which is based on ABS data and projections.
Not all TBI and SCI patients are admitted to hospital ('downside' risk). It is likely that some moderate TBI cases are not admitted to hospital.[34]	None.	Utilising hospital separations to estimate incidence may have lead to conservative estimates for moderate TBI.

[34] Source: Personal consultation with VSTR, 20/4/09

Some TBI may be included in code S09.9: "Unspecified injury of head", however, this code also likely includes other non-TBI injuries, e.g. injuries to the face or ear[35]. Thus, this code was excluded as a TBI code in the analysis by Helps et al (2008).	None.	As a consequence incidence estimates are likely to be conservative.

TABLE B4: SEVERITY OF TBI CASES CAPTURED BY STATE TRAUMA REGISTRIES (VICTORIA AND QUEENSLAND), 2007-08

State	Mild	Moderate	Severe
Victoria	68%	11%	20%
Queensland	72%	7%	21%
Mean	**70%**	**9%**	**21%**

Source: VSTR (2009) and QTR (2009).

The number of incident cases for Australia in 2008 was estimated to be 1,762 for moderate TBI and 3,781 for severe TBI (TABLE B5, Table 2-12). This is equivalent to incidence rates of 8.2 and 17.3 cases per 100,000 persons for moderate and severe TBI respectively. The number of cases was estimated to be over double for males relative to females, and the highest SCI case count was estimated to be for young adults aged 15-25. The age and gender distribution for moderate and severe (combined) TBI is demonstrated in Figure B1.

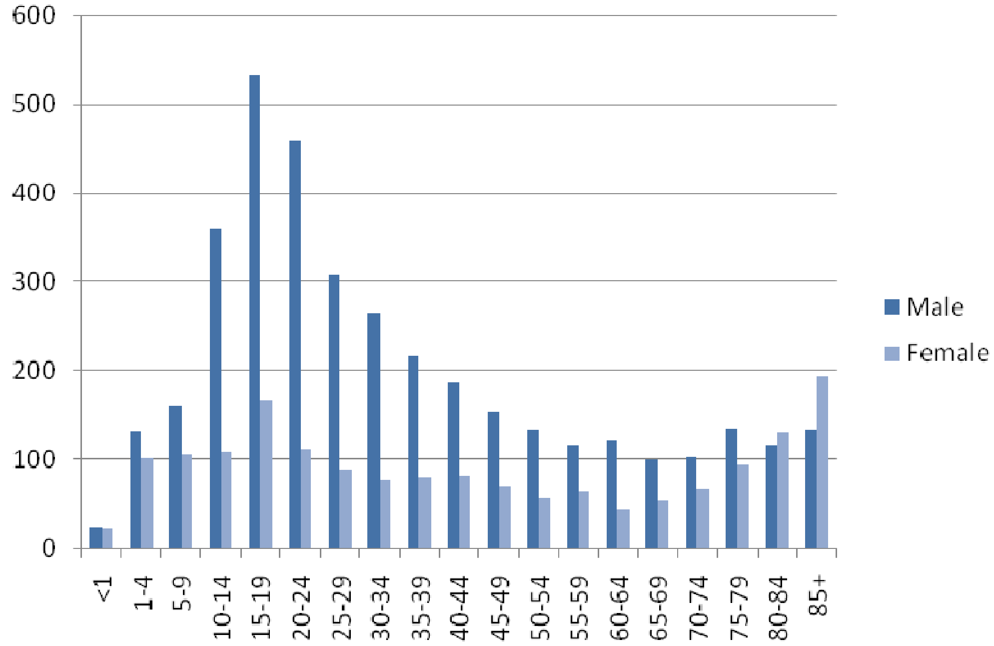
TABLE B5: INCIDENT CASES OF TBI BY SEVERITY AND GENDER, AUSTRALIA, 2008

Moderate TBI			Severe TBI			Combined total
Male	Female	Total	Male	Female	Total	
1,200	562	1,762	2,557	1,161	3,718	5,480

Source: Estimate based on data reported by Helps et al (2008), AIHW NHMD (2009), VSTR (2009), QTR (2009).

[35] Source: Personal communication Epworth Hospital Health Information Services, April 2009.

FIGURE B1: INCIDENT CASES OF TBI BY AGE, GENDER AND SEVERITY, AUSTRALIA, 2008



Source: Estimate based on data reported by Helps et al (2008), AIHW NHMD (2009), VSTR (2009), QTR (2009).

> For the year 2008 in Australia, there were an estimated 1,762 new cases of moderate TBI and 3,718 new cases of severe TBI.

SCI

The NISU recently published data on SCI separations and healthcare utilisation for the six year period between 1 July 1999 and 30 June 2005 based on data retrieved from the AIHW NHMD (Henley 2009). Within this report, NISU reported the number of incident cases of SCI to be 4,592 based on the following inclusion criteria:

- **definition of SCI**: ICD-10 codes listed in TABLE B6 below;
- **diagnosis**: Cases included SCI as principal or additional diagnosis with a principle diagnosis of injury; and
- **time period:** 1999-2000 to 2004-05.

TABLE B6: ICD-10 CODES MAPPING TO SCI UTILISED BY HENLEY (2009)

ICD-10-AM code	Description
S14.0	Concussion and oedema of cervical spinal cord
S14.10–S14.13	Other and unspecified injuries of cervical spinal cord
S14.70–S14.78	Functional level of cervical spinal cord injury
S24.0	Concussion and oedema of thoracic spinal cord
S24.10–S24.12	Other and unspecified injuries of cervical thoracic cord
S24.70–S24.77	Functional level of thoracic spinal cord injury
S34.0	Concussion and oedema of lumbar spinal cord
S34.1	Other injury of lumbar spinal cord
S34.70–S34.76	Functional level of lumbar spinal cord injury
T06.0	Injuries of brain and cranial nerves with injuries of nerve and spinal cord at neck level
T06.1	Injuries of nerves and spinal cord involving other multiple body regions
T09.3	Injury of spinal cord, level unspecified
T91.3	Sequelae of injury of spinal cord

Source: Henley et al (2009).

The proportion of all (4,592 over six years) incident cases during the 2004-05 was estimated as 887 (TABLE B7). Henley (2009) also reported the level of spinal cord lesion (cervical, thoracic and lumbar) for the incident SCI cases. These were mapped to associated SCI severity categories[36] to estimate the distribution of the 887 incident cases as 39% paraplegia and 61% quadriplegia[37].

TABLE B7: SCI SEPARATIONS AND CASES, 1999-2000 TO 2004-05 AND 2004-05

	Time period	Incident separations	Incident SCI cases		
			Male	Female	Total
(a)	1999-2000 to 2004-05 (6 years)	9,086	3,245	1,347	4,592
(b)	2004-05 (1 year)	1,756	627*	260*	887*
	b/a	19%			

Source: Henley et al (2009). * Estimated as 19% of (a) consistent with time distribution of incident separations.

The incidence of paraplegia and quadriplegia in Australia in 2008 was estimated based on the incident number of cases reported by Henley for 2004-05 and the following adjustments:

- applied an age distribution (refer to methods for TBI); and
- increased incidence consistent with population growth between 2005 to 2008 (refer to methods for TBI).

[36] Assumes that cervical level maps to quadriplegia, thoracic and lumbar levels map to paraplegia. See Table A3 in Appendix A.

[37] Compares to mean across three states (Victoria, NSW and Qld): Paraplegia (47%), Quadriplegia (53%). See Table A4 in Appendix A.

The number of incident cases for Australia in 2008 was estimated to be 359 for paraplegia and 560 for quadriplegia (TABLE B8). This is equivalent to incidence rates of 1.7 and 2.6 cases per 100,000 persons for paraplegia and quadriplegia respectively. SCI was estimated to be five-fold more common in males relative to females, and similar to TBI, cases were most common in young adults aged 15-25. The age and gender distribution for paraplegia and quadriplegia (combined) is illustrated in Figure B2.

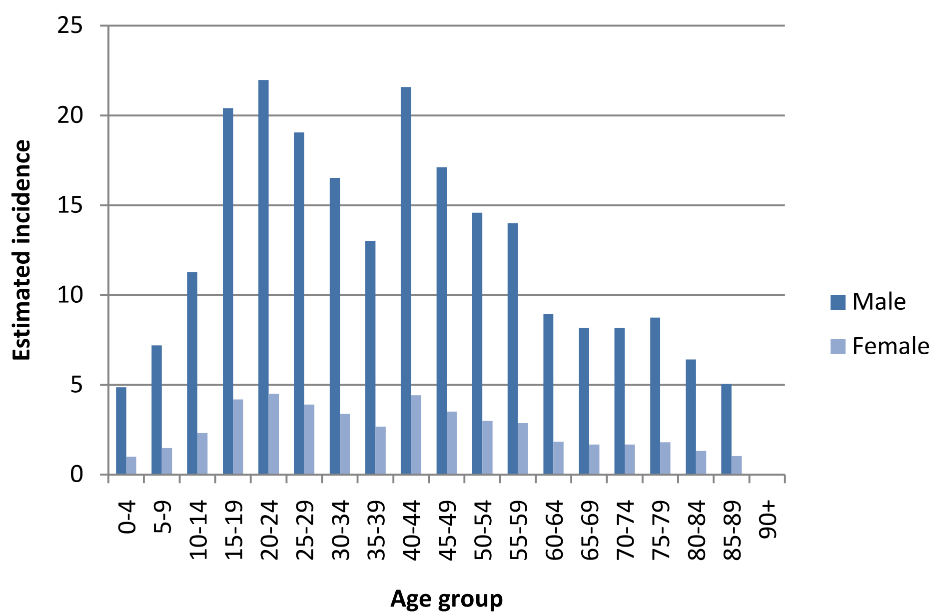
TABLE B8: INCIDENT CASES OF SCI BY SEVERITY AND GENDER, AUSTRALIA, 2008

Paraplegia			Quadriplegia			Combined total
Male	Female	Total	Male	Female	Total	
254	105	359	396	164	560	919

Source: Estimate based on data reported by Henley et al (2008), AIHW NHMD (2008).

This incidence of SCI estimated for this analysis in 2008 (919 SCI cases) is higher than the estimated incidence reported by Cripps (2008) for 2006-07 (300-400 SCI cases). However, the estimate reported by Cripps (2008) probably under-reported total incidence because it only included adult cases admitted to the six Australian hospitals with specialist SCI units. Henley (2009) reported the number of SCI-related separations admitted to hospitals with and without SCI units as 3,806 and 5,280 (ratio of 1:1.39) respectively. Multiplying the incidence (median 350) reported by Cripps (2008) by 1.39 to estimate the additional cases admitted to hospitals without SCI unit provides a total incidence estimate of 835 (for 2006-07), fairly similar to the 919 estimated for this study for the year 2008.

FIGURE B2: INCIDENT CASES OF SCI BY AGE, GENDER AND SEVERITY, AUSTRALIA, 2008



Source: Estimate based on data reported by Henley et al (2008), AIHW NHMD (2008)

For the year 2008 in Australia, there were an estimated 359 new cases of paraplegia and 560 new cases of quadriplegia.