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ISCRR
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Patients with severe, catastrophic acquired brain injury – using data linkages to identify outcomes

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Executive Summary

Traumatic brain injury (TBI) represents a significant health burden both internationally and in Australia. Maximising function and reducing complications are highly important for reducing the burden of severe TBI. Discharge planning from the acute setting for severe TBI patients is often complex as recovery is slow, long-term outcome is uncertain, and there are limited facilities available in Victoria for the provision of care.

The Department of Health (Victoria) and the Transport Accident Commission (TAC) have funded a new rehabilitation model for Victoria, involving opening of a new TBI rehabilitation facility at the Caulfield site of Alfred Health as a statewide service for severe TBI. It is anticipated that the new rehabilitation model of care will impact on length of stay, functional status and living situation, as well as mortality. Evaluation of the impact of the introduction of the new model of rehabilitation care requires high quality baseline data for comparison.

The key purpose of this study was to describe the profile of severe TBI in Victoria, where patients are managed acutely and sub-acutely in the Victorian State Trauma System, and the long term outcomes of these patients. A specific aim was to establish the feasibility of linking Victorian State Trauma Registry (VSTR) data with Victorian Admitted Episode Dataset (VAED) to provide sufficient baseline data for evaluation of the new ABI unit based at Alfred Health which is due to open in 2014.

Key messages

i. The VSTR, select TAC cost data, and VAED data were successfully linked for all 251 severe TBI survivors to hospital discharge from July 2009 to June 2012, establishing proof of concept of data linkage as a tool for evaluating the impact of the new ABI unit.

ii. At discharge, 65 per cent of severe TBI patients are discharged to an inpatient rehabilitation facility with the vast majority discharged to a private rehabilitation facility. Patients discharged to inpatient rehabilitation were more severely injured overall, but were younger and more likely to be TAC compensable, than patients discharged to another hospital or care facility. Of the 29 per cent of patients discharged to another facility, 88 per cent were discharged to a public hospital for further care. Patients discharged to private inpatient rehabilitation units were almost exclusively TAC compensable.

iii. Data provided by the Victorian Data Linkage (VDL) unit from the VAED included the data necessary to evaluate care costs in the further evaluation of the new ABI unit. However, the exclusion of hospital name for private hospitals in the extract limited the capacity to understand the flow of patients in the healthcare system and future linkages will need to seek approval for the disclosure of private hospital names to ensure robust analysis of change in discharge practice and outcomes over time.

iv. While admission and discharge FIM data were provided with the VDL extract, these were complete in only a quarter of inpatient rehabilitation admissions, and none were provided from private rehabilitation facilities. This will impact on the capacity to evaluate the effectiveness of rehabilitation across the full patient population. Further consultation and negotiation with data custodians will be

needed to ensure that these important data items are made available for the next phase of the project.

v. The VSTR successfully linked with the TAC claims data for more than 95 per cent of severe TBI cases with a fund listed as TAC. The data provided by TAC were robust, providing direct costs for these cases. These data will be highly valuable for the next phase of the project, as more than half of severe TBI patients in Victoria are TAC compensable.

vi. The long term follow-up rates for severe TBI patients captured by the VSTR were high at all time points post-injury, ensuring robust estimates of functional, return to work and other key patient outcomes.

Finally, as a proof of concept project, the project was successful and the learnings will guide the next phase of the project, which will compare discharge destination, costs and outcomes of patients through the trauma system before and after the introduction of the new ABI unit.

Purpose

The key purpose was to describe the profile of severe TBI in Victoria, where patients are managed acutely and sub-acutely in the Victorian State Trauma System, and the long term outcomes of these patients. The specific aim was to establish the incidence, outcomes (hospital length of stay, functional status, living situation and mortality) and inpatient costs of severe TBI managed at The Alfred and Royal Melbourne Hospital (RMH) in Victoria from July 2009 to June 2012.

A key focus was to establish the feasibility of linking Victorian State Trauma Registry (VSTR) data with Victorian Admitted Episode Data (VAED) to provide sufficient baseline data for evaluation of the new ABI unit based at Alfred Health which is due to open in 2014.

Rationale

Traumatic brain injury (TBI) represents a significant health burden both internationally and in Australia[1-3]. Severe TBI leaves many individuals with severe disability and chronic conditions that affect their health-related quality of life and often require long-term health care, resulting in profound economic and social costs[3-5]. The total lifetime cost of a severe TBI case has been estimated at $4.8 million [6].

Maximising function and reducing complications are highly important for reducing the burden of severe TBI[1, 7-9]. The timeframe for improvement following severe TBI is long, and specialised post-acute care is critical in ensuring the best outcome for patients[8]. Discharge planning from the acute setting for severe TBI patients is often complex as recovery is slow, long-term outcome is uncertain, and there are limited facilities available in Victoria for the provision of care. Access to rehabilitation is often limited to select subsets of severe TBI, potentially limiting functional outcome and increasing the individual, family and economic burden of severe TBI. Previous studies have shown improvement in functional outcome for even the most severely injured patients admitted to rehabilitation[9].

The Department of Health (Victoria) and the Transport Accident Commission (TAC) have funded a new rehabilitation model for Victoria, involving opening of a new TBI rehabilitation facility at the Caulfield site of Alfred Health as a statewide service for severe TBI. It is anticipated that the new rehabilitation model of care will impact on length of stay (LOS), functional status and living situation, as well mortality. Evaluation of the impact of the introduction of the new model of rehabilitation care requires high quality baseline data for comparison.

Methods

Study design

A retrospective cohort study of cases from 2009 to 2012 was undertaken using routinely collected hospital data.

Participants

All adult (aged 18 years and over) patients with a severe TBI registered by the VSTR with a date of injury from July 2009 to June 2012 (inclusive) were included. A severe TBI was defined as a Glasgow Coma Scale (GCS) score from 3 to 8 and an Abbreviated Injury Scale (AIS) head injury severity score >2. Cases definitively managed at The Alfred and Royal Melbourne Hospital were included. While all 138 trauma receiving hospitals in the state contribute data to the registry, 85% of severe TBI cases are definitively managed at the state's adult major trauma services, The Alfred and Royal Melbourne Hospital.

Ethics statement

Ethics approval for this project was obtained from the Alfred Health Human Research Ethics Committee (HREC) – project number 496/13; and from the Melbourne Health HREC – project number 2013.273.

Procedures

Sources of data

Data for this project were sourced from the following datasets:

i. Victorian State Trauma Registry (VSTR) - The VSTR captures data about all major trauma patients in Victoria, irrespective of which hospital provides their care[10, 11]. Demographic and injury event details, compensable status, definitive hospital of care details, in-hospital outcomes, and injury diagnosis and severity outcomes were extracted for the index admission. Pre-injury employment status and occupation, pre-injury disability, level of education, and 6-, 12- and 24-month functional, return to work and work disability, and place of residence data were also extracted for this study.

ii. Victorian Admitted Episodes Dataset (VAED) - The VAED is the Victorian Department of Health's morbidity data collection. Data are collected on all admitted patients from Victorian public and private acute hospitals including rehabilitation centres, extended care facilities and day procedure centres. Month and year of admission, age group, ICU admission, ventilation hours, hospital length of stay, ICD-10-AM diagnosis and procedure codes, mode of arrival at hospital, Barthel scores on admission and discharge, FIM scores on admission and discharge, clinical sub-program, marital status, and discharge destination (accommodation type) were collected for all admissions to hospital since the index VSTR admission.

iii. The Transport Accident Commission (TAC) is Victoria's third party, no-fault insurer for transport-related injury. Total TAC claim, in-hospital, out-of hospital treatment, loss of earnings, attendant care, equipment, home services, long term

care and other costs at 6-months, 12-months and 24-months post-injury were included in the VSTR dataset for linkage with the VAED.

iv. Victorian Registry of Births, Deaths and Marriages (BDM) - BDM data will be used to identify post-discharge deaths and long term mortality in the study population.

Linkage process

TBI cases were identified through the VSTR. The VSTR routinely receives linked TAC claims data and the VSTR and TAC data were linked prior to submission to the Victorian Data Linkage Unit (VDLU) at the Department of Health. Prior to submission, the TAC claim number and all other TAC data that were not for inclusion in this project were removed from the extract. At the VDLU, linkage staff added the VAED and BDM data to the linked VSTR and TAC data. The VSTR and VAED data were linked using patient name, date of birth, residential address, hospital UR number, admission number, date of admission and date of discharge. Once the VSTR/TAC extract was linked with the VAED by VDLU staff, all identifiers were removed by the VDLU and a de-identified dataset returned to the project investigators for analysis via their secure site. Approval was received from the Department of Health custodian to allow identification of public hospitals but not private hospitals in the linked dataset. Admissions until the end of 2013 were included in the linked dataset.

Data Analysis

Summary statistics were used to describe the study population and their outcomes. Data are presented as proportions. For continuous variables with a normal distribution data were summarised using the mean and standard deviation (SD). Where data were not normally distributed, the data were summarised using the median and interquartile (IQR) range or were categorised for analysis. The outcomes of interest included:

i. **Acute hospital length of stay** – defined as the total number of bed days in acute hospital

ii. **Rehabilitation hospital length of stay** – defined as the total number of inpatient rehabilitation days, where the patient was admitted to inpatient rehabilitation.

iii. **Cumulative mortality** – in-hospital, 6-month, 12-month and 24-month mortality.

iv. **Rehabilitation Effectiveness –** defined by subtracting the patient's admission score on the measure of functional status from his/her discharge score in rehabilitation or sub-acute care for patients admitted to inpatient rehabilitation.

v. **Rehabilitation Efficiency -** defined as the change in functional status from admission to discharge divided by the rehabilitation LOS only. A shorter LOS for a given change in FIM rating has a higher efficiency rating.

vi. **Discharge destination** – defined as discharge destination from their final recorded hospital as recorded in hospital separations data. Discharge destination codes include private residence/accommodation, mental health residential, aged care residential or transition care bed based program.

vii. **Inpatient costs:** Inpatient costs (in A$ in year 2012) can be derived using a case-mix approach based on Australian National Diagnosis Related Groups (AN-

DRG) (Commonwealth Department of Health and Family Services, Canberra, Australia). Cost weights for AN-DRG from the health department were requested.

viii. **Functional outcome –** defined as the Glasgow Outcome Scale – Extended (GOS-E) score collected at 6, 12 and 24-months post-injury by the VSTR.

ix. **Return to work** – defined as return to paid employment and collected at 6, 12 and 24-months post-injury by the VSTR.

x. **Health related quality of life** – measured using the EQ-5D score collected from patient or proxy at 6, 12 and 24-months post-injury by the VSTR.

xi. **Costs** - Health care utilisation (including ambulance, hospital, medical and paramedical), equipment and modifications (including equipment and technology to assist with daily living and transportation, avoid medical complications, and provide home assistance or ventilation), long-term care costs (accommodation, respite, paid attendant care, and supported community services) was obtained for TAC compensable cases.

xii. **Living situation** – the place of residence of severe TBI patients was obtained from the data collected at the routine follow-up interviews of VSTR patients at each follow-up time point.

All analyses were performed using Stata Version 13 (StataCorp, College Station, Texas) and an *a priori* alpha level of 0.05 used for all tests.

Research findings and implications

Overview of all cases

Between July 2009 and June 2012, there were 453 severe TBI patients definitively managed at The Alfred and RMH. The overall in-hospital death rate was 45 per cent (n=202), leaving 251 cases who survived to hospital discharge. Of the 239 cases managed at The Alfred, 98 (41%) died during their hospital stay and 141 (59%) survived to hospital discharge. At the RMH, 104 of the 214 cases (48%) died during their hospital stay and 110 (51%) survived to hospital discharge.

Table 1 summarises the demographic and injury event profile of severe TBI cases by in-hospital survival status. Overall, a higher proportion of severe TBI cases who died in-hospital were older, female, intentional self-harm incidents, non-compensable and falls-related (Table 1).

Table 1: Demographic and injury profile of severe TBI cases by in-hospital survival status

Population descriptor		In-hospital deaths (n=202)	Survivors to discharge (n=251)
Age group	N (%)		
	18-24 years	26 (12.9)	79 (31.5)
	25-34 years	33 (16.3)	71 (28.3)
	35-44 years	24 (11.9)	38 (15.1)
	45-54 years	22 (10.9)	21 (8.4)
	55-64 years	24 (11.9)	22 (8.8)
	65-74 years	31 (15.3)	13 (5.2)
	75+ years	42 (20.8)	7 (2.8)
Gender	N (%)		
	Male	145 (71.8)	192 (76.5)
	Female	57 (28.2)	59 (23.5)
Intent of injury	N (%)		
	Unintentional	156 (77.6)	206 (85.1)
	Intentional assault	13 (6.5)	28 (11.6)
	Intentional self-harm	28 (13.9)	6 (2.5)
	Intent cannot be determined	4 (2.0)	2 (0.8)
Cause of injury	N (%)		
	Motor vehicle	36 (18.1)	79 (32.6)
	Low fall	44 (22.1)	29 (12.0)
	High fall	34 (17.1)	29 (12.0)
	Pedestrian	26 (13.1)	34 (14.0)
	Struck by/collision with object or person	14 (7.0)	30 (12.4)
	Motorcycle	12 (6.0)	22 (9.1)
	Pedal cyclist	7 (3.5)	15 (6.2)
	Other	26 (13.1)	4 (1.6)
Compensable status	N (%)		
	TAC	72 (35.8)	147 (59.0)
	Medicare	118 (58.7)	94 (37.8)
	Private insurance	5 (2.5)	5 (2.0)
	WorkSafe Victoria	6 (3.0)	3 (1.2)

Of note, deaths in-hospital had a comparable median ISS to hospital survivors and a lower proportion of cases with a GCS on arrival at the definitive hospital of care (Table 2). However, 83 per cent of in-hospital deaths had an AIS head injury severity score of 5-6 representing “critical” and “maximal” injuries compared to 35 per cent of in-hospital survivors. The overall hospital length of stay, ICU admission rate, ICU length of stay and ventilated hours were substantially lower for in-hospital deaths. The median length of hospital stay for a severe TBI case at a major trauma service was 23 days, which is well above the median of 8 days for all major trauma patients in Victoria (Table 2).

Table 2: Injury severity and in-hospital outcomes of severe TBI cases by in-hospital survival status

Population descriptor		In-hospital deaths (n=202)	Survivors to discharge (n=251)
Injury Severity Score	Median (IQR)	27 (25-38)	27 (20-34)
GCS on arrival	N (%)		
	3	130 (64.4)	207 (83.8)
	4	17 (8.4)	1 (0.4)
	5	14 (6.9)	4 (1.6)
	6	22 (10.9)	6 (2.4)
	7	13 (6.4)	18 (7.3)
	8	6 (3.0)	11 (4.4)
AIS head severity score	N (%)		
	3	11 (6.9)	70 (28.1)
	4	18 (11.3)	91 (36.5)
	5-6	130 (82.7)	88 (35.3)
ICU stay	N (%)		
	No	54 (26.9)	11 (4.4)
	Yes	147 (73.1)	239 (95.6)
ICU length of stay	Median (IQR) days	3 (2-8)	11 (6-18)
Ventilated time	Median (IQR) hours	61 (19-171)	173 (71-308)
Hospital length of stay	Median (IQR) days	1.9 (0.4-6.7)	23 (13-35)

Discharge destination

Linkage with the VAED data was successful for all 251 VSTR cases who survived to hospital discharge. Of the 251 cases, 162 (64.5%) were discharged for Level 1 or Level 2 inpatient rehabilitation, 72 (28.7%) were discharged to another type of facility for care, and 17 (6.8%) were discharged directly to home. Of the 72 discharged to another type of facility for care, 60 were for “other acute care”, 8 were discharged to a Geriatric Evaluation and Management program and 4 were discharged to acute mental health or alcohol and drug program facilities.

Table 3 shows the demographic and injury event profile of survivors of severe TBI by discharge destination. The vast majority of patients discharged directly home were less than 35 years of age. A higher proportion of patients discharged to inpatient rehabilitation were also younger compared to those discharged to another facility for care. No patient aged 75 years of age or more was discharged to an inpatient rehabilitation facility or directly to home. Almost half of the severe TBI patients discharged directly home from hospital were victims of assault (Table 3). The level of socioeconomic disadvantage or remoteness was similar across each discharge destination. A higher proportion of patients discharged to inpatient rehabilitation were TAC compensable (Table 3).

Table 3: Demographic and injury event profile of severe TBI cases by discharge destination (survivors to hospital discharge only)

Population descriptor		Home (n=17)	Inpatient rehabilitation (n=162)	Other destination (n=72)	All cases (n=251)
Age group	N (%)				
	18-24 years	9 (52.9)	55 (33.9)	15 (20.8)	79 (31.5)
	25-34 years	6 (35.3)	42 (25.9)	23 (31.9)	71 (28.3)
	35-44 years	0 (0.0)	30 (18.5)	8 (11.11)	38 (15.1)
	45-54 years	0 (0.0)	19 (11.7)	2 (2.8)	21 (8.4)
	55-64 years	1 (5.9)	10 (6.2)	11 (15.3)	22 (8.8)
	65-74 years	1 (5.9)	6 (3.7)	6 (8.3)	13 (5.2)
	75+ years	0 (0.0)	0 (0.0)	7 (9.7)	7 (2.8)
Gender	N (%)				
	Male	16 (94.1)	122 (75.3)	54 (75.0)	192 (76.5)
	Female	1 (5.9)	40 (24.7)	18 (25.0)	59 (23.5)
Intent of injury	N (%)				
	Unintentional	9 (52.9)	138 (88.5)	59 (85.5)	206 (85.1)
	Intentional assault	8 (47.1)	12 (7.7)	8 (11.6)	28 (11.6)
	Intentional self-harm	0 (0.0)	5 (3.2)	1 (1.5)	6 (2.5)
	Intent cannot be determined	0 (0.0)	1 (0.6)	1 (1.5)	2 (0.8)
Cause of injury	N (%)				
	Motor vehicle	2 (11.8)	56 (35.7)	21 (30.9)	79 (32.6)
	Pedestrian	1 (5.9)	28 (17.8)	5 (7.3)	34 (14.0)
	Struck by/collision with object or person	8 (47.0)	14 (8.9)	8 (11.8)	30 (12.4)
	Low fall	1 (5.9)	13 (8.3)	15 (22.1)	29 (12.0)
	High fall	3 (17.7)	15 (9.6)	11 (16.2)	29 (12.0)
	Motorcycle	0 (0.0)	18 (11.5)	4 (5.9)	22 (9.1)
	Pedal cyclist	2 (11.8)	11 (7.0)	2 (2.9)	15 (6.2)
	Other	0 (0.0)	2 (1.3)	2 (2.9)	4 (1.7)

Population descriptor		Home (n=17)	Inpatient rehabilitation (n=162)	Other destination (n=72)	All cases (n=251)
Compensable status	N (%)				
	TAC	5 (29.4)	112 (70.0)	30 (41.7)	147 (59.0)
	Medicare	11 (64.7)	44 (27.5)	39 (54.2)	94 (37.8)
	Private insurance	1 (5.9)	3 (1.9)	1 (1.4)	5 (2.0)
	WorkSafe Victoria	0 (0.0)	1 (0.6)	2 (2.8)	3 (1.2)
IRSAD quintile	N (%)				
	1-2 (Most disadvantaged)	2 (12.5)	14 (8.9)	8 (11.9)	24 (10.0)
	3-4	1 (6.2)	16 (10.2)	5 (7.5)	22 (9.2)
	5-6	2 (12.5)	31 (19.7)	20 (29.8)	53 (22.1)
	7-8	6 (27.5)	49 (31.2)	14 (20.9)	69 (28.8)
	9-10 (Least disadvantaged)	5 (31.2)	47 (29.9)	20 (29.8)	72 (30.0)
Remoteness index	N (%)				
	Major city	13 (81.3)	112 (71.3)	49 (73.1)	174 I72.5)
	Inner regional area	3 (18.7)	40 (25.5)	16 (23.9)	59 (24.6)
	Outer regional/remote area	0 (0.0)	5 (3.2)	2 (3.0)	7 (2.9)

Overall, the patients discharged directly home were less severely injured TBI cases in all measures of severity and in-hospital outcome (Table 4). Similarly, patients discharged to inpatient rehabilitation were more severely injured than patients discharged to other acute care facilities (Table 4).

Table 4: Injury severity and in-hospital outcomes of severe TBI cases by discharge destination (survivors to hospital discharge only)

Population descriptor		**Home (n=17)**	**Inpatient rehabilitation (n=162)**	**Other destination (n=72)**	**All cases (n=251)**
Injury Severity Score	Median (IQR)	18 (17-25)	29 (22-38)	25 (17-30)	27 (20-34)
GCS on arrival	N (%)				
	3-4	11 (68.8)	139 (0.6)	58 (80.6)	208 (84.2)
	5-6	1 (6.2)	6 (3.8)	3 (4.2)	10 (4.1)
	7-8	4 (25.0)	14 (8.8)	11 (15.3)	29 (11.7)
AIS head severity score	N (%)				
	3	6 (37.5)	40 (24.8)	24 (33.3)	70 (28.1)
	4	6 (37.5)	62 (38.5)	23 (31.9)	91 (36.6)
	5-6	4 (25.0)	59 (36.7)	25 (34.7)	88 (35.3)
Isolated head injury?	N (%)				
	No	3 (17.7)	77 (47.5)	23 (31.9)	103 (41.0)
	Yes	14 (82.3)	85 (52.5)	49 (68.1)	148 (59.0)
Neurosurgery?	N (%)				
	No	12 (70.6)	32 (19.8)	27 (37.5)	71 (28.3)
	Yes	5 (29.4)	130 (80.2)	45 (62.5)	180 (71.7)
ICU stay	N (%)				
	No	4 (23.5)	2 (1.2)	5 (6.9)	11 (4.4)
	Yes	13 (76.5)	159 (98.8)	67 (93.1)	239 (95.6)
ICU length of stay	Median (IQR) days	2 (2-6)	14 (8-19)	8 (3-14)	11 (6-18)
Ventilated time	Median (IQR) hours	23 (12-50)	215 (105-343)	112 (28-229)	173 (71-308)
Hospital length of stay	Median (IQR) days	8 (3-16)	25 (15-39)	22 (11-36)	23 (13-35)

Of the patients discharged to inpatient rehabilitation, 72 per cent (n=103) were admitted to a private rehabilitation unit for care. Seven public rehabilitation units accounted for the remainder of rehabilitation admissions, of which 26 were to Royal Talbot Rehabilitation Centre, 6 to Caulfield General Medical Centre, and 3 to Royal Melbourne Hospital Royal Park Campus, and the remainder to a variety of public rehabilitation units. The median (IQR) rehabilitation length of stay for severe TBI cases was 42 (21-84) days. The maximum length of inpatient rehabilitation stay recorded was 286 days.

The key difference between severe TBI patients discharged to private inpatient rehabilitation and those discharged to public rehabilitation facilities was the compensable status of the patient (Table 5). Only 32 per cent of patients discharged to public rehabilitation units were TAC compensable, compared to 91 per cent of patients discharged to private rehabilitation units. Age was a distinguishing factor between patients discharged to another care facility and those discharged to inpatient rehabilitation, with 18 per cent of patients discharged to another care facility aged 65 years or greater, compared to 3.7 per cent of patients discharged to inpatient rehabilitation (Table 5).

Table 5: Severity, compensable and age profile by specific discharge destination

	All survivors to discharge	**Discharged to other facility**	**Discharged to private rehab**	**Discharged to public rehab**
	(n=251)	**(n=72)**	**(n=103)**	**(n=59)**
Severity				
GCS ≤ 5	212 (85.8)	58 (80.6)	91 (90.1)	51 (87.9)
GCS 6-8	35 (14.2)	14 (19.4)	10 (9.9)	7 (12.1)
Compensable status				
TAC	147 (59.0)	30 (41.7)	94 (91.3)	18 (31.6)
Medicare	94 (37.8)	39 (54.2)	5 (4.8)	39 (68.4)
Private Insurance	5 (2.0)	1 (1.4)	3 (2.9)	0 (0.0)
VWA	3 (1.2)	2 (2.8)	1 (1.0)	0 (0.0)
Age				
18-64 years	231 (92.0)	59 (81.9)	98 (95.1)	58 (98.3)
65+ years	20 (8.0)	13 (18.1)	5 (4.9)	1 (1.7)

Of the patients discharged to inpatient rehabilitation, Functional Independence Measure (FIM) scores on arrival and discharge from the rehabilitation unit were available for 36 cases. None were provided in the linked dataset for private hospital admissions. The motor, cognitive, and total FIM scores, along with the rehabilitation effectiveness (FIM discharge-FIM admission) and rehabilitation efficiency (FIM discharge-FIM admission divided by length of stay) are shown in Table 6. There was clear improvement in the FIM motor, cognitive and total FIM scores from inpatient rehabilitation to inpatient rehabilitation discharge (Table 6).

Table 6: FIM scores for patients admitted to inpatient rehabilitation (n=36)

Measure		Mean (SD)
Admission	Motor	48.3 (26.5)
	Cognitive	14.1 (7.5)
	Total	62.4 (31.3)
Discharge	Motor	79.2 (19.2)
	Cognitive	26.3 (7.6)
	Total	105.5 (25.3)
Rehabilitation effectiveness		43.1 (25.56)
Rehabilitation efficiency		100.9 (24.9)

Of the 71 patients discharged to other care facilities, 9 (12.7%) cases were discharged to a private facility, and the remainder to 16 separate public facilities, under a variety of clinical specialties (Figure 1).

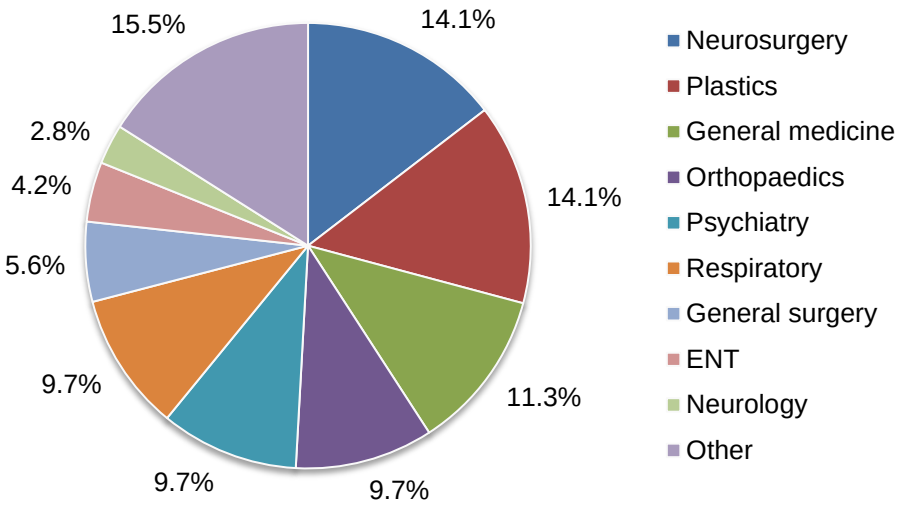

Figure 1: Admission specialty of severe TBI patients discharged to facilities other than inpatient rehabilitation

Longer term outcomes and hospital readmission

None of the severe TBI patients discharged directly to home were readmitted to hospital in the first 2-years post injury. Of the patients discharged to inpatient rehabilitation, the median (IQR) number of subsequent hospital admissions in the first 2-years post-injury was 1 (0-3) with a range of 0 to 28 admissions. Of the patients discharged to another facility following definitive care, the median (IQR) number of admissions was 1 (0-3) with a range of 0 to 19 admissions.

Of the 251 survivors to hospital discharge, valid GOS-E scores were collected at 6-months post-injury for 239 (95.2%) patients, and for 227 (90.4%) at 12-months post-injury. Complete GOS-E scores at 24-months post-injury were available for 215 (85.7%) patients, with the lower follow-up rate at 24-months reflecting the need to send the file for linkage prior to completion of all 24-month follow-ups in this patient cohort.

There were no deaths after hospital discharge in the cohort in the first 6-months post-injury, and only 2 deaths overall in the cohort who survived to hospital discharge by 12-months post-injury. The distribution of GOS-E scores by discharge destination following acute care are shown in Figure 2. The median GOS-E score improved from upper moderate disability to lower good recovery from 6-months to 24-months post-injury in the group discharged directly home from hospital. The median GOS-E score remained stable at each time point at lower moderate disability for the group discharged to inpatient rehabilitation, although the proportion classified as severe disability decreased from 38 per cent at 6-months post-injury to 25 per cent at 24-months post-injury. In the group discharged to other care facilities, the median GOS-E score rose from lower upper severe disability to lower moderate disability from 6-months to 24-months post-injury (Figure 2).

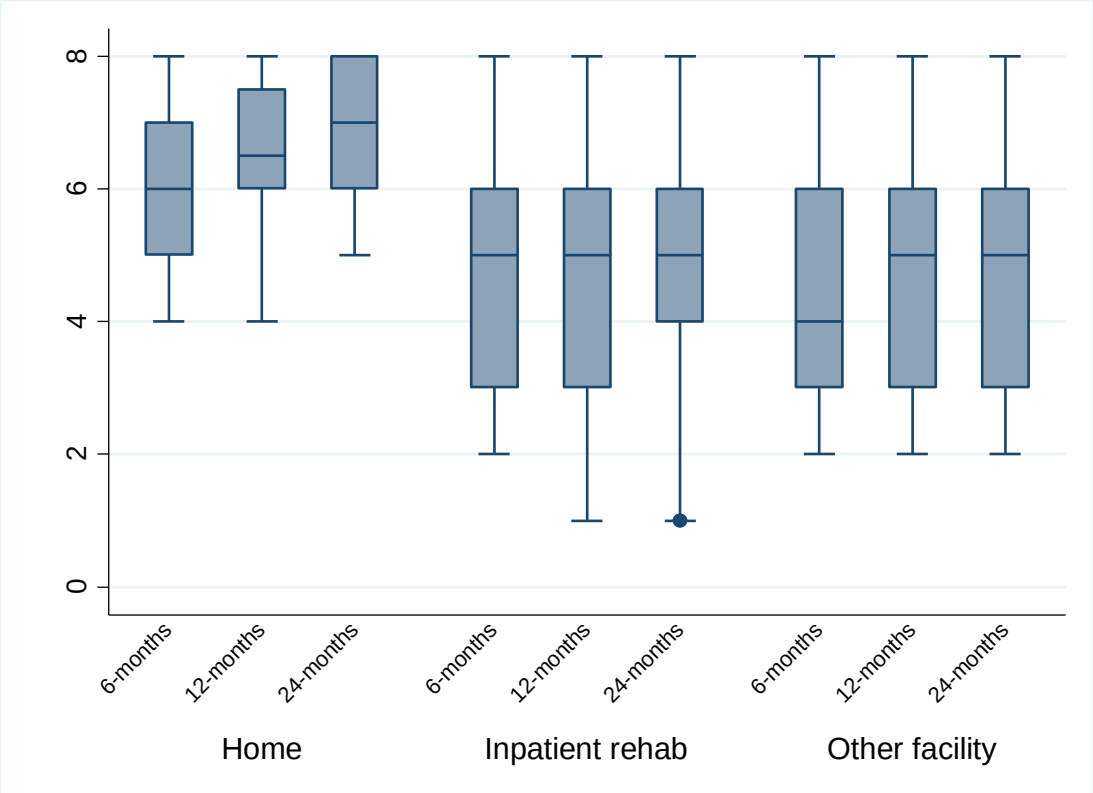

Figure 2: Distribution of GOS-E scores by discharge destination at each follow-up time point

The place of residence of severe TBI patients at each follow-up time point is shown in Figure 3 by discharge destination from the acute setting. The vast majority of patients discharged directly home from hospital remained at home (Figure 3). The proportion of patients discharged to inpatient rehabilitation who were living at home at each time point post-injury was higher than for patients discharged to other facilities. One in five patients discharged to another care facility were living in a nursing home or other aged care facility at 24-months post-injury, compared to 6.5 per cent of patients discharged to inpatient rehabilitation.

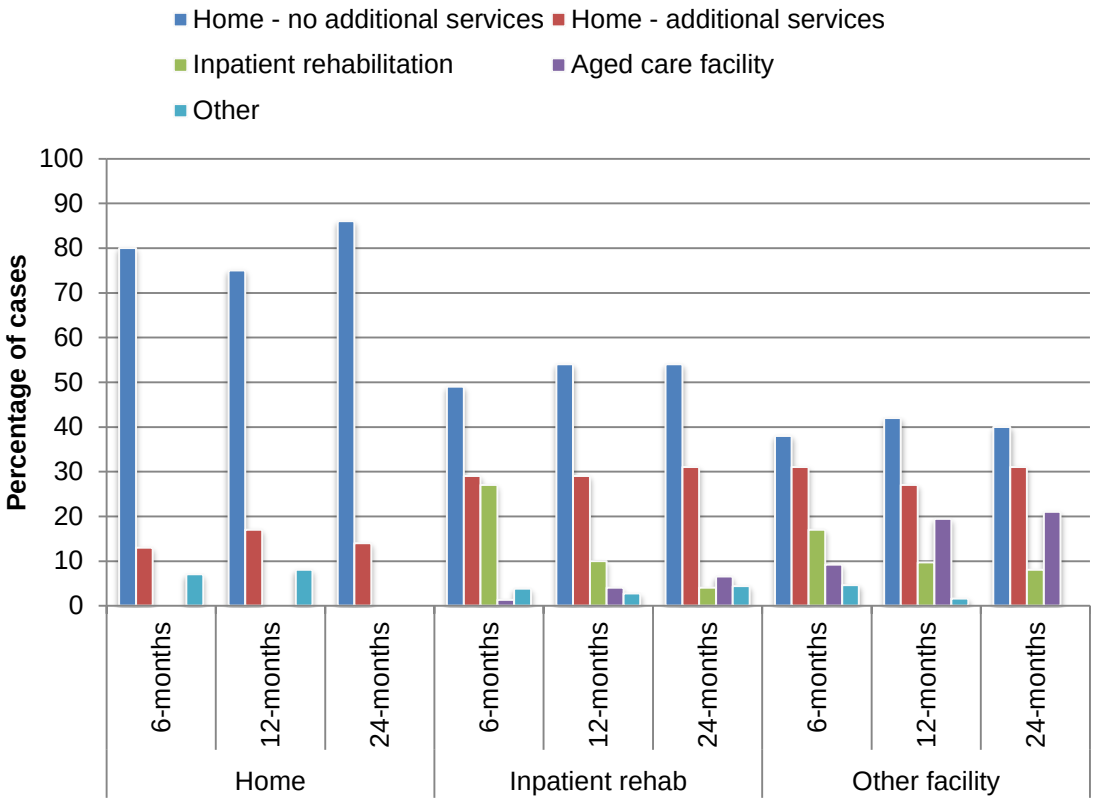

Figure 3: Place of residence at follow-up by discharge destination from the acute setting

One-hundred and seventy-eight (70.9%) severe TBI patients were known to be working prior to injury. Only two were aged more than 65 years at the time of injury. By 24-months post-injury, 50 per cent had returned to work. There was improvement in return to work rates over time for patients discharged directly home and those discharged to inpatient rehabilitation (Figure 4). Return to work rates were much lower for patients who were discharged to another facility after initial acute care, with 26 per cent returned to work by 24-months post-injury.

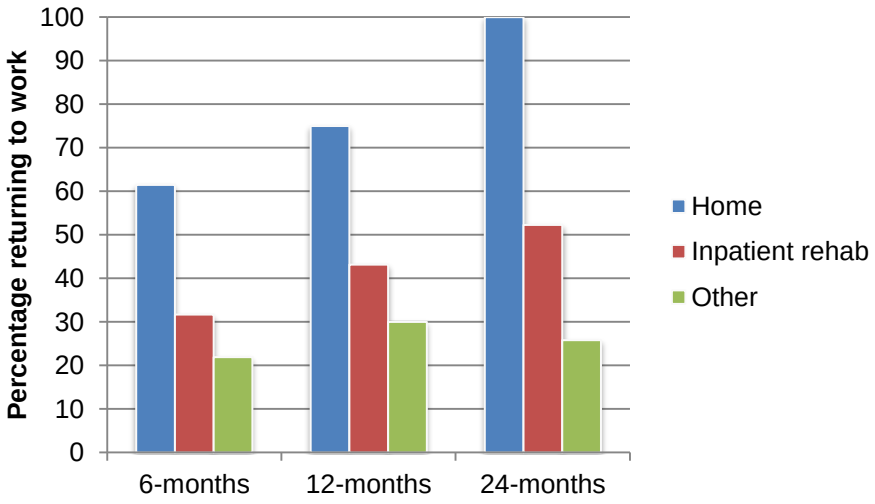

Figure 4: Percentage of patients returning to work after severe TBI

TAC claim costs

Of the 251 survivors to hospital discharge, 147 were recorded as TAC compensable and 140 (95.2%) had valid linked cost data from the TAC through the routine linkage of the VSTR with CRD data. Of the 140 TAC cases, 110 were discharged to inpatient rehabilitation, 26 to another facility and 4 were discharged directly to home. The claim costs by type of costs at each time point overall, and by discharge destination, are shown in Table 7. Patients discharged to home were excluded from the sub-group comparison as there were too few cases to generate robust summary statistics in this group.

The median in-hospital costs were largely comparable between the group discharged to inpatient rehabilitation and those discharged to another facility, with most in-hospital costs expended in the first 6-months post-injury (Table 7). Out-of-hospital treatment costs and loss of earnings payments increased over time. By 24-months post-injury, the median in-hospital cost for a severe TBI TAC claim was $210,179, with the median loss of earnings payment exceeding $50,000 and attendant care above $60,000.

Table 7: TAC claim costs for severe TBI in the first 24-months post-injury

		All TAC claims (n=140)	Inpatient rehab (n=110)	Other facility (n=26)
6-months	**Median (IQR) $**			
	In-hospital costs	$201,578 (116,303-286,902)	$210,322 (126,725-295,726)	$195,658 (97,304-283,973)
	Out-of-hospital treatment costs	$6,333 (3,370-9,915)	$6,939 (3,939-9,964)	$4,524 (2,720-9,640)
	Loss of earnings (n=83)	$16,809 (11,236-25,420)	$17,959 (11,425-25,419)	$16,718 ($10,597-27,701)
	Attendant care (n=52)	$3,610 (1002-15,543)	$780 (109-12,737)	$8,074 (1,369-42,100)
	Equipment (n=110)	$483 (233-1,104)	$483 (246-1,243)	$408 (191-1,073)
12-months	**Median (IQR) $**			
	In-hospital costs	$208,892 (118,037-297,216)	$213,608 (126,725-300,682)	$200,382 (97,304-294,311)
	Out-of-hospital treatment costs	$15,282 (8,359-23,060)	$18,184 (9,170-26,361)	$9,718 (5,619-19,816)
	Loss of earnings (n=83)	$32,277 (13,778-46,834)	$35,539 (15,748-47,060)	$33,126 (12,159-45,539)
	Attendant care (n=52)	$24,810 (7,590-53,721)	$24,318 (8,074-53,030)	$25,301 (3,050-54,412)
	Equipment (n=110)	$979 (305-3961)	$899 (284-3,832)	$1,367 (379-4,699)
24-months	**Median (IQR) $**			
	In-hospital costs	$210,179 ($119,329-299,126)	$212,219 (122,200-304,656)	$197,130 (113,380-299,126)
	Out-of-hospital treatment costs	$29,017 (12,581-46,145)	$30,692 (15,125-52,314)	$22,990 (11,080-43,591)
	Loss of earnings (n=83)	$50,034 (15,834-75,474)	$51,085 (22,407-76,302)	$41,729 (9,428-74,771)
	Attendant care (n=52)	$64,724 (3,116-177,735)	$65,021 (13,264-167,556)	$16,978 (1,369-219,843)
	Equipment (n=110)	$1,374 (364-5,684)	$1,120 (305-3,346)	$3,787 (379-24,888)

Summary of the important findings

The key purpose of this study was to describe the profile of severe TBI in Victoria, where patients are managed acutely and sub-acutely in the Victorian State Trauma System, and the long term outcomes of these patients. A specific aim was to establish the feasibility of linking VSTR data with VAED to provide sufficient baseline data for evaluation of the new ABI unit based at Alfred Health which is due to open in 2014.

The important findings were:

vii. The VSTR, select TAC cost data, and VAED were successfully linked for all 251 severe TBI survivors to hospital discharge from July 2009 to June 2012, establishing proof of concept of data linkage as a tool for evaluating the impact of the new ABI unit in time.

viii. At discharge, 65 per cent of severe TBI patients are discharged to an inpatient rehabilitation facility with the vast majority discharged to a private rehabilitation facility. Patients discharged to inpatient rehabilitation were more severely injured overall, but were younger and more likely to be TAC compensable, than patients discharged to another hospital or care facility. Of the 29 per cent of patients discharged to another facility, 88 per cent were discharged to a public hospital for further care.

ix. Data provided by the VDL from the VAED included DRG and WEIS data which will make hospitalisation cost analyses possible in the further evaluation of the new ABI unit. However, the exclusion of hospital name for private hospitals in the extract limits the capacity to understand the flow of patients in the healthcare system and future linkages will need to seek approval for the disclosure of private hospital names to ensure robust analysis of change in discharge practice and outcomes over time.

x. While admission and discharge FIM data were provided with the VDL extract, these were complete in only a quarter of inpatient rehabilitation admissions, and none were provided from private rehabilitation facilities. This will impact on the capacity to evaluate the effectiveness of rehabilitation across the full patient population. Further consultation and negotiation with data custodians will be needed to ensure that these important data items are made available for the next phase of the project.

xi. The VSTR successfully linked with the TAC claims data for more than 95 per cent of severe TBI cases with a fund listed as TAC. The data provided by TAC were robust, providing direct costs for these cases. These data will be highly valuable for the next phase of the project, as more than half of severe TBI patients in Victoria are TAC compensable.

xii. The long term follow-up rates for severe TBI patients captured by the VSTR were high at all time points post-injury, ensuring robust estimates of functional, return to work and other key patient outcomes.

Finally, as a proof of concept project, the project was successful and the learnings will guide the next phase of the project, which will compare discharge destination, costs and outcomes of patients through the trauma system before and after the introduction of the new ABI unit.

Use of the research

The results of this project show that data linkage between the VSTR, TAC claims data and the VAED can provide a comprehensive overview of the flow of severe TBI patients through the Victorian State Trauma System in both the acute and post-acute phases of care. The linked data adds value to single, routinely collected datasets since the information required to better understand the state of rehabilitation in Victoria for adults who suffer severe TBI is not found in one place alone.

The project represents a successful proof of concept regarding data linkage, forming the foundation for evaluating the impact of the new TAC and Department of Health funded ABI unit opening at Alfred Health. The project also highlights areas of improved data quality and access needed to maximise the evaluation of the new ABI unit.

Potential impact of the research

The impact of the research is the enhanced understanding of the experiences of severe TBI patients in Victoria prior to the opening of the new ABI unit. The findings provide proof of concept of data linkage of existing data sources as an important component of the evaluation of the new ABI unit and form the foundation for the evaluation. The key learnings highlight areas for improvement in the next linkage to ensure enhance the capacity to evaluate any changes in care and flow through the trauma system following the introduction of the new unit.

References

1. Dikmen S, Machamer J, Powell J, Temkin N: **Outcome 3 to 5 years after moderate to severe traumatic brain injury.** *Archives of Physical Medicine and Rehabilitation* 2003, **84**.
2. Ratcliff G, Colantonio A, Escobar M, Chase S, Vernich L: **Long-term survival following traumatic brain injury.** *Disability and Rehabilitation* 2005, **27:**305-314.
3. Baguley I, Nott M, Howie A, Simpson G, Browne S, King A, Hodgkinson A: **Late mortality after severe traumatic brain injury in New South Wales: a multicentre study.** *Medical Journal of Australia* 2012, **196:**40-45.
4. Jennett B: **Outcome after severe head injury.** In *Head injury.* Edited by Reilly P, Bullock R. London: Chapman and Hall; 1997
5. Cameron C, Purdie D, Kliewer E, McClure R: **Ten-year outcomes following traumatic brain injury: A population-based cohort.** *Brain Injury* 2008, **22:**437-449.

6. Economics A: **The economic cost of spinal cord injury and traumatic brain injury in Australia.** Melbourne: Access Economics; 2009.

7. Hart T, Whyte J, Polansky M, Kersey-Matusiak G, Fidler-Sheppard R: **Community outcomes following traumatic brain injury: Impact of race and preinjury status.** *Journal of Head Trauma Rehabilitation* 2005, **20:**158-172.

8. Khan F, Baguley I, Cameron I: **Rehabilitation after traumatic brain injury.** *Medical Journal of Australia* 2003, **178:**290-295.

9. Whitlock J, Hamilton B: **Functional outcome after rehabilitation for severe traumatic brain injury.** *Archives of Physical Medicine & Rehabilitation* 1995, **76:**1103-1112.

10. Cameron P, Finch C, Gabbe B, Collins L, Smith K, McNeil J: **Developing Australia's first statewide trauma registry - What are the lessons?** *Australian and New Zealand Journal of Surgery* 2004, **74:**424-428.

11. Cameron P, Gabbe B, McNeil J, Finch C, Smith K, Cooper D, Judson R, Kossmann T: **The trauma registry as a state-wide quality improvement tool.** *Journal of Trauma* 2005, **59:**1469-1476.

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