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MERRC-TAC Linkage Report: Identifying different patterns of outcome and their predictors

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1. About this report

The Monash-Epworth Rehabilitation Research Centre (MERRC) MERRC is currently participating in an international collaboration with the aim of identifying clusters of individuals with traumatic brain injury. In two initial studies using a large cohort of TBI participants in the USA, Sherer et al.[1,2] identified five groups of individuals who differed on 12 dimensions that assessed cognitive, personal strengths, environmental, and performance validity factors. Following these results, MERRC began conducting interviews with individuals using these same 12 dimensions in order to examine whether this five-group solution could be applied to Australian individuals with TBI. A recent report has subsequently confirmed that the five-group solution can also be applied in the Australian cohort. The current report presents findings regarding these five groups and their association with community participation outcomes and TAC service utilisation.

2. Background

Traumatic brain injury (TBI) results in a range of cognitive, behavioural, emotional, and physical changes that may persist many years following the injury. Scores on the Glasgow Coma Scale (GCS), loss of consciousness, and duration of post-traumatic amnesia (PTA) have traditionally been used to classify the severity of the TBI. Although these indices, especially duration of PTA, aid significantly in the prediction of outcome they cannot capture other injuries that may also impact outcomes. In addition, individuals with similar GCS scores or duration of PTA often display different symptoms and outcomes due to the influence of a broad range of other factors.

Following a TBI, clinicians provide recommendations to guide treatment planning and monitor recovery. Recommendations are provided regarding individuals' needs for supervision, capacity for decision-making, and ability to return to work. These individualised assessments are based on the severity of injury, medical complications, cognitive impairments, physical functioning, emotional distress, environmental support, and other symptoms reported by the patient. The appropriateness of these assessments and recommendations for treatment relies on the training and experience of clinicians. Because of the complexity of combining numerous tests, symptoms, and reports, there has been a need for an integrated approach, or higher-level conceptual model, that provides guidance to clinicians when they are forming treatment plans for patients. An approach that classifies individuals with TBI into groups or clusters has the potential to aid in treatment planning and prediction of prognosis.

A recent study by Sherer et al.[1] examined whether individuals could be classified in the post-acute period using a broad range of individual characteristics. They administered measures of cognitive functioning, performance validity, reported cognition, emotional, neurobehavioural and physical symptoms, personal strengths, physical functioning, and environmental supports. The results indicated that 12 dimensions could be used to characterise individuals with TBI in years following injury. The dimensions, and the measures used to define each dimension, are list in Table 1 (refer to the Methods section for greater measure details).

Table 1. Measures defining 12 dimensions used to characterise individuals with TBI.

Dimension	Measures
Memory	Letter number sequencing
	RAVLT Trials 1-5
Cognitive processing speed	Trails A
	Wechsler coding
Verbal fluency	Verbal fluency FAS
Self-reported cognitive symptoms	TBI-QOL cognition—general concerns
Independence and self-esteem	TBI-QOL Self-esteem
	TBI-QOL Independence
Resilience	TBI-QOL Resilience
Emotional distress	TBI-QOL Anxiety
	TBI-QOL Emotional and behavioural dyscontrol
Postconcussive symptoms	Neurobehavioural symptoms inventory
Physical symptoms	TBI-QOL Headache
	TBI-QOL Pain interference
Physical functioning	TBI-QOL Upper extremity
Economic and family support	Economic quality of life
	FAD General functioning
Performance validity	Word memory test

Note. Adapted from Sherer et al.[1]

In a follow-up study, Sherer et al.[2] sought to identify clusters of individuals with TBI who differed from each other on their profiles on the 12 dimensions. Their results indicated that individuals could be clustered into five clinically meaningful groups. Seeing the potential in this classification system, MERRC initiated a collaboration with TIRR Memorial Hermann, Houston, Texas, to examine whether these same five clusters, or groups, also applied to Australian individuals with TBI. The results provided support for the stability of the five

groupings between the USA and Australian cohorts. Specifically, this report confirmed the presence of five clinically meaningful groups in the Australian TBI sample (refer to figure 1):

- Group 1 is characterised by intact cognitive functioning, strengths in self-perception and environmental support and denial of negative signs and symptoms while showing symptom validity.
- Group 2 is characterised by greater cognitive difficulties, intermediate levels of strengths, environmental support, and physical functioning. They displayed adequate symptom validity.
- Group 3 displayed relatively intact functioning over all dimensions. They displayed the most intact cognitive functioning, intermediate levels of strengths, environmental support, and physical functioning, as well as adequate symptom validity.
- Group 4 displayed relatively intact cognitive functioning but reported higher levels of symptoms and poorer levels of personal strengths. They, nevertheless, displayed intact symptom validity.
- Group 5 displayed poorer cognitive performance and reported higher levels of symptoms and lower strengths. This group fell below the cut-off for symptom validity.

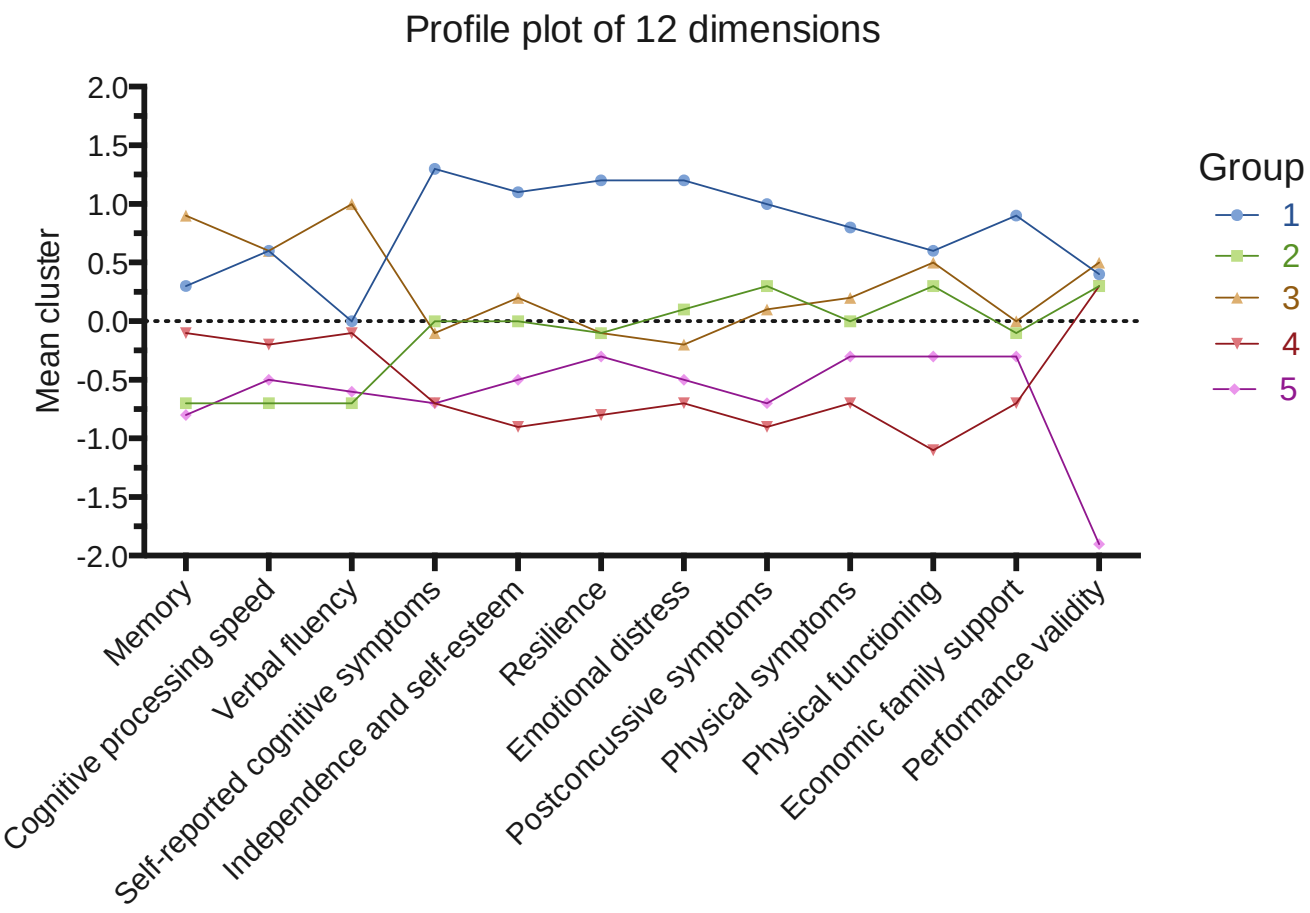

Figure 1. Dimension score for the five groups.

Although it has been shown that the Australian TBI cohort can be clustered into five clinically meaningful profiles we do not yet know whether these groups differ on meaningful outcomes, such as community participation. In addition, there is no evidence that these five groups differ in regards to their TAC claim profiles. Demonstrating differences between the groups in regards to recovery outcomes and service utilisation will provide further evidence and justification for these groups. It would further highlight the potential need for different treatment options depending on the individual's profile in regards to the 12 dimensions.

3. Aims

1. To examine whether differences exists between cluster groups in regards to background and injury-related factors.
2. To examine differences between cluster groups in regards to community participation outcomes, as assessed using the Participation Assessment with Recombined Tools-Objective (Part-O).
3. To examine differences between cluster groups in regards to accrued costs for long-term care, medical, and allied health services .

4. Methods

Potential participants were identified from the longitudinal head injury database at Epworth Hospital. Participants who were living in the community were initially contacted following their routine follow-up to determine their interest in participating in this study. Inclusion criteria was a documented TBI of any severity, aged 18 to 64 years, capacity to give informed consent, and ability to complete all study measures in English, and being 6 months to 10 years post injury.

Medical and demographic information was collected from medical records and other research records. Measures included six tests of cognition, and 12 questionnaires assessing aspects of impairments, symptoms, and supports, and one performance validity test. Specifically, these were:

- Wechsler Adult Intelligence Scale-IV Letter Number Sequencing subtest – Assesses working memory, attention, and mental control
- Wechsler Adult Intelligence Scale-IV Coding subtest – Assesses processing speed
- Rey Auditory Verbal Learning Test acquisition trials – Assesses memory acquisition and retention
- Trail Making Test Part A – Assesses processing speed
- Verbal Fluency Test (FAS) – Assesses semantic memory

- Word Memory Test – Assesses performance validity on cognitive testing. Poor validity could represent and attempt to perform poorly, inattention, or other response sets that result in non-neurologic patterns of responses.
- TBI Quality of Life measurement system – A comprehensive health related quality of life measurement system developed specifically for individuals with TBI. The domains assessed by the TBI QOL included:
    - *Upper extremity* – Fine motor skills, self-care, household tasks
    - *Pain Interference* – Extent to which pain affects task completion, emotional status, relationship with others
    - *Headache pain* – Severity and frequency of headache and interference with task completion
    - *Self-esteem* – Self-esteem, shame, insecurity, being incomplete as a person
    - *Anxiety* – Feelings of nervousness, worry, tension, fear
    - *Resilience* – Self-efficacy, positive attitude, self-confidence, internal locus of control
    - *Emotional and Behavioural Dyscontrol* – Impulsivity, restlessness, sensitivity, lability
    - *Cognition-General concerns* – Slowed thinking, confusion, losing track of events or conversations
    - *Independence* – Reliance on help from others, satisfaction with level of independence
- Family Assessment Device General Functioning Scale – Measures family functioning
- Economic Quality of Life Scale – Measures ability to afford basic needs and wants as well as dependence on others to meet financial needs
- Neurobehavioural Symptom Inventory – measures the frequency of symptoms reported by individuals that have sustained TBI over the preceding two weeks
- Participation Assessment with Recombined Tools-Objective – measures patient-reported participation outcomes

5. Data analysis

Initial chi-square and linear regressions were conducted to examine whether the five groups differed in regard to background and injury-related factors. Chi-square analyses were conducted for the dichotomous and categorical variables. Linear regression analyses were also conducted to examine whether the groups differed on the Part-O. The Part-O productivity, social relations, and out-and-about subscale, as well as averaged and balanced scores of were used as outcome measures. The Part-O balanced score takes into

consideration the variability between the three subscale scores. Greater variability between the subscales is penalised in the final balanced score.

A series of regression analyses was conducted to examine whether groups differed in regards to service utilisation following their accident. Regression models predicting accrued costs and service utilization controlled for time since accident as participants were assessed at varying time-points. This was done to control for the expected pattern whereby individuals at longer time-points post-injury would be expected to have utilised more services. Robust variance estimation was used for total cost and service utilization models. Robust variance estimation was used due to concerns over meeting assumptions, such as normality and observations with large residuals. A linear regression was conducted to examine whether groups differed in regards to total costs. A negative binomial regression was conducted to examine whether participants differed in regards to total, or overall, number of services. A negative binomial regression was used to model the number, or counts, of service utilisation types. A series of zero-inflated Poisson regressions was conducted to examine whether the groups differed in regards to specific types of services utilization. Zero-inflated Poisson regressions were conducted due to the high frequency of individuals not utilising any of the specific service types. To account for this inflation in zeros, this particular regression model allows one to specify the variable that may account for the presence of no, or zero, service utilisation. For these models this variable was group membership.

6. Results

Recruitment comprised a sample of 170 individuals with TBI. Eight individuals were excluded due to missing values on the Word Memory Test, leaving a final sample of 162 individuals. Of these, 35 (21.6%) were in group 1, 32 (19.8%) in group 2, 39 (24.1%) in group 3, 30 (18.5%) in group 4, and 26 (16.1%) in group 5. Background and injury related information for the overall sample and specific groups can be found in Table 2 below.

Table 2. Participant characteristics

	Total n=162 M(SD); %	Group 1 n= 35 M(SD); %	Group 2 n=32 M(SD); %	Group 3 n=39 M(SD); %	Group 4 n=30 M(SD); %	Group 5 n=26 M(SD); %
Background factors						
Age at assessment	44.0 (16.2)	45.1 (15.4)	35.2 (16.5)	48.7 (15.8)	46.7 (15.5)	43.5 (15.2)
Months post-injury assessed	55.8 (33.9)	62.1 (36.6)	54.5 (37.8)	54.8 (24.7)	48.2 (35.0)	59.0 (36.1)
Gender (male)	77%	77%	88%	69%	70%	81%
Years of education at assessment	13.5 (3.2)	14.5 (3.1)	12.6 (2.4)	14.8 (3.7)	12.8 (2.7)	12.2 (2.7)
Hours worked per week prior to injury	39.7 (18.8)	46.1 (14.4)	35.4 (17.1)	32.0 (21.4)	41.8 (15.5)	46.1 (21.2)
Annual earning prior to injury (categorical)						
$0 – $39,999	40%	33%	46%	39%	42%	43%
$40,000 - $89,999	29%	13%	38%	27%	31%	38%
$90,000 or more	31%	53%	15%	33%	27%	19%
Married/defacto/relationship	57%	66%	50%	67%	40%	62%
Drugs prior to injury (yes)	93%	83%	81%	87%	90%	73%
Alcohol prior to injury (yes)	81%	89%	84%	87%	70%	69%
Dwelling (Metropolitan Melbourne)	67%	71%	59%	69%	60%	73%
Accommodation						
Lives independently, alone, or with friends	28%	32%	16%	38%	20%	27%
Lives at home with parents	23%	18%	50%	10%	17%	23%
Lives at home with spouse	49%	50%	34%	51%	60%	50%
Injury-related factors						
Cause of injury						
Car accident	41%	29%	56%	36%	53%	35%
Bicycle accident	10%	17%	6%	13%	7%	8%
Fall	11%	14%	9%	15%	3%	12%
Pedestrian	12%	6%	13%	10%	17%	19%
Work related	12%	20%	6%	10%	7%	19%
Motorcycle	12%	14%	9%	15%	13%	8%
GCS emergency room						
Mild (13-15)	39%	36%	29%	44%	37%	50%
Moderate (9-12)	19%	24%	26%	17%	17%	12%
Severe (3-8)	42%	39%	45%	39%	47%	38%
PTA	22.4 (22.5)	16.4 (13.8)	24.0 (23.2)	20.0 (25.8)	29.1 (25.5)	24.9 (21.6)
Acute car length of stay	18.7 (17.3)	16.8 (11.9)	17.2 (13.2)	17.9 (22.2)	24.0 (21.8)	18.1 (13.6)
Inpatient length of stay	43.1 (34.1)	31.2 (16.5)	40.1 (32.3)	45.2 (33.9)	54.7 (48.0)	46.0 (31.6)
Spine/back	40%	32%	59%	33%	53%	23%
Abdomen	31%	24%	22%	28%	50%	35%
Chest	54%	53%	59%	56%	60%	38%
Limb	52%	41%	53%	54%	70%	38%
Facial	37%	47%	41%	26%	33%	38%

6.1 Relationship between background, injury-related factors, and group membership

The groups were found to differ in age at assessment, years of education, hours worked per week prior to injury, accommodation, and the frequency of moderate or major back injuries (Table 3; Figure 2). Group 2 was significantly younger compared to groups 3 and 4 and had fewer years of education compared to group 3. Group 3 worked more hours prior to injury, compared to groups 1 and 5. Group 1 were more highly educated than groups 4 and 5. Group 2 was more likely to be living with their parents at the time of the accident. Groups 2 and 4 had a higher frequency of back injuries. Importantly, however, the groups did not differ in regards to the time-post-injury assessed and the severity of their injuries.

Table 3. Univariate analyses between group, background, and injury-related variables

	n	F/ χ^2	p
Background factors			
Age at assessment	162	3.68	**.007**
Months post-injury assessed	162	.76	.55
Gender	162	4.28	.37
Years of education at assessment	162	5.23	**.0006**
Hours worked per week prior to injury	145	3.72	**.0007**
Annual earning prior to injury (categorical)	136	12.76	.13
Married/defacto/relationship	162	6.97	.14
Drugs prior to injury	162	3.45	.50
Alcohol prior to injury	161	7.06	.15
Dwelling	162	2.32	.69
Accommodation	160	20.23	**.019**
Injury-related factors			
Cause of injury	162	18.72	.54
GCS emergency room	156	4.56	.82
PTA	156	1.50	.20
Acute car length of stay	162	.90	.47
Inpatient length of stay	158	2.05	.09
Spine/back	161	11.84	**.02**
Abdomen	161	7.49	.13
Chest	161	3.44	.50
Limb	161	7.45	.12
Facial	161	4.02	.40

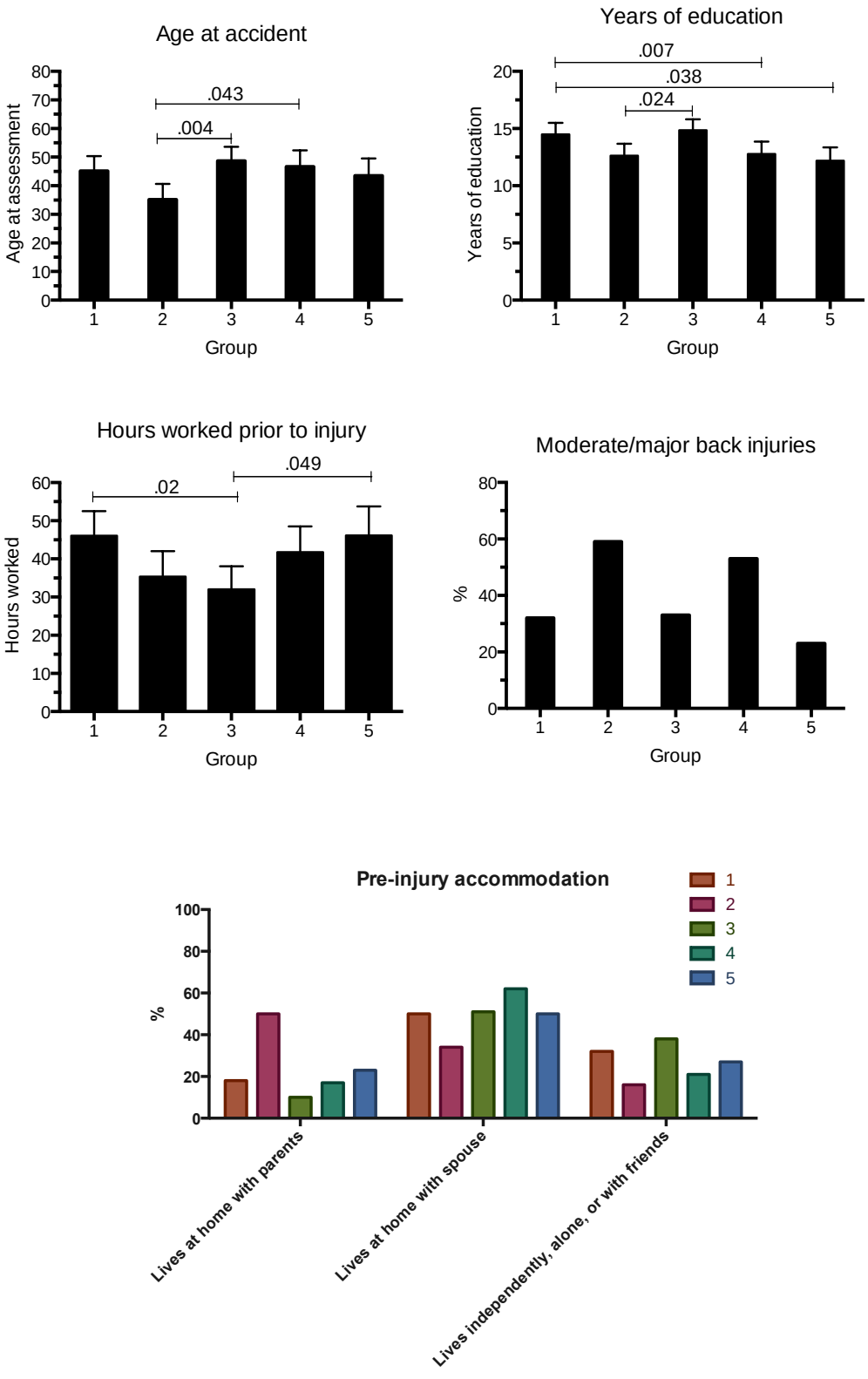

Figure 2. Background and injury-related variables that significantly differentiated between groups

6.2 Relationship between group membership and community participation

Significant group differences were found for the productivity and social relation subscales of the Part-O. Group 1 was found to score significantly higher on both the productivity and social subscales, compared to groups 4 and 5. For the productivity subscale, group 3 also score more highly than group 4. The out-and-about subscale did not differentiate between the groups. Group 1 also scored significantly more highly on the Part-O averaged scored, compared to groups 2, 4, and 5. Group 3, however, also scored more highly compared to groups 4 and 5. Group 1 scored more highly on the balanced Part-O score compared to groups 4 and 5. Group scored more highly compared to group 4 on the balanced score.

Table 4. Regressions between group and the Participation Assessment with Recombined Tools-Objective

	n	F	p
Part-O subscales			
Productivity subscale score	162	7.32	**<.001**
Social relations subscale score	162	4.91	**.001**
Out-and-about subscale score	162	1.34	.26
Part-O Totals			
Averaged total	162	9.59	**<.001**
Balanced total	162	6.38	**<.001**

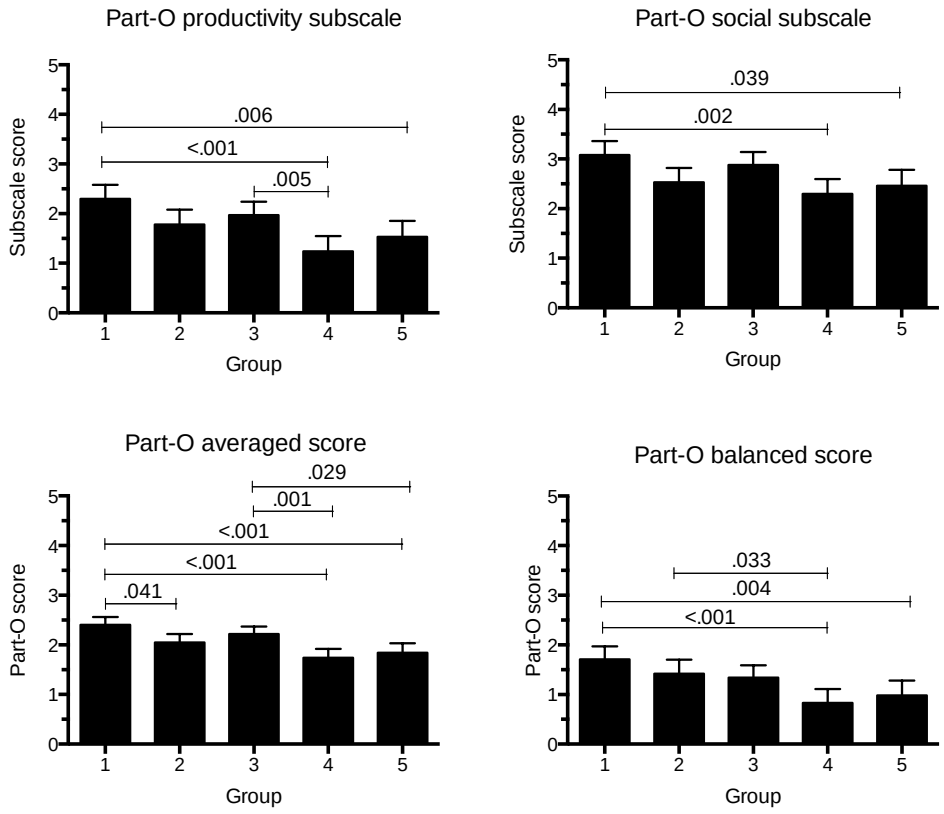

Figure 3. Part-O subscale and overall scores that significantly differentiated between groups

6.3 Relationship between group membership and service utilisation

Significant group differences were found in overall inflated costs and number of services utilised since the accident. Groups 1 and 3 accrued fewer total costs and number of services compared to groups 4 and 5. Group 2 only utilised fewer services compared to group 5. Significant group differences were also evident for specific service types. Group 1 utilised the fewest LTC services compared to all other groups. Group 5 used a greater number of LTC services compared to groups 3 and 4. Groups 4 and 5 used the greater number of GP and specialist practitioner services. Groups 3 and 4 used a significantly greater number of GP and specialist services compared to groups 1, 2 and 3.

Overall, groups 4 and 5 were also found to use a greater number of analgesic, antidepressant, neuropathic pain, and schedule 8 medications. Specifically, groups 3, 4 and 5 used a greater number of analgesic medications compared to group 2. Groups 4 and 5 used a greater number of antidepressants compared to groups 1 and 3. Group 5 used a greater number of antidepressants compared to group 4. Group 2 used a greater number of antidepressants compared to group 1. Groups 1, 3, 4 and 5 used a greater number of neuropathic pain medications compared to group 2, whereas group 4 also used a greater amount compared to group 1. A similar finding was present for schedule 8 medications, whereby group 2 used fewer schedule 8 medications compared with all groups.

Table 5. Association between group and service utilisation

	n	F/ χ^2	p
Total inflated costs (up to Sept 2015)	102	2.85	**.019**
Total number of services (up to Sept 2015)	102	22.20	**.0005**
Loss of earnings / loss of earning capacity	101	6.52	.26
Long term care	101	262.27	**<.001**
GP	101	46.05	**<.001**
Specialist practitioner	101	34.15	**<.001**
Surgery	101	2.49	.78
Pathology	101	6.33	.78
Radiology	101	9.97	.08
Musculoskeletal therapies	101	7.00	.22
Vocational	101	10.49	.06
Psychology and psychiatry	101	7.79	.17
Social work	101	16.02	.17
Analgesics	101	16.53	**.007**
Antidepressants	101	673.83	**<.001**
Neuropathic pain	101	267.17	**<.001**
Schedule 8 medications	101	25.50	**<.001**

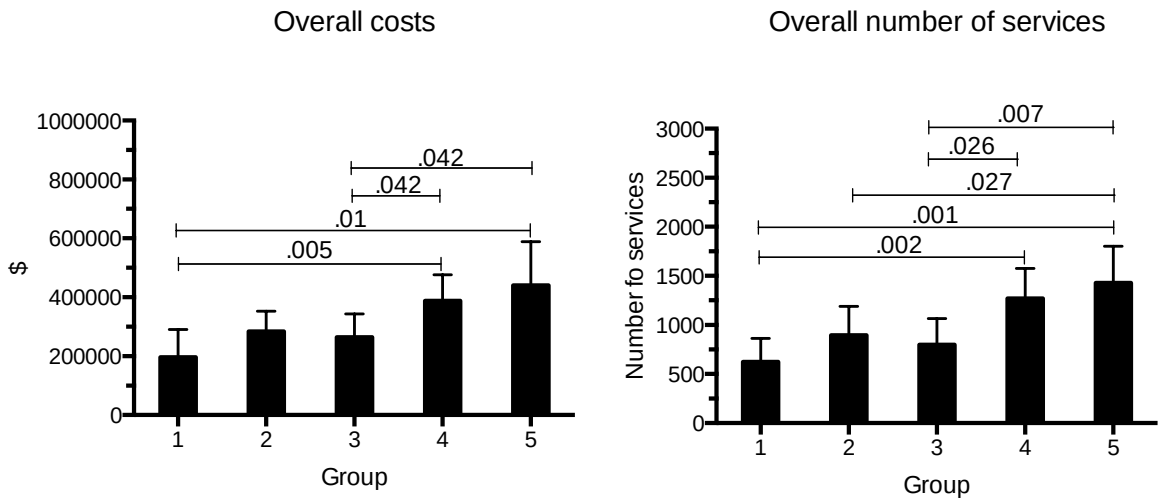

Figure 4. Association between group and overall costs and number of services

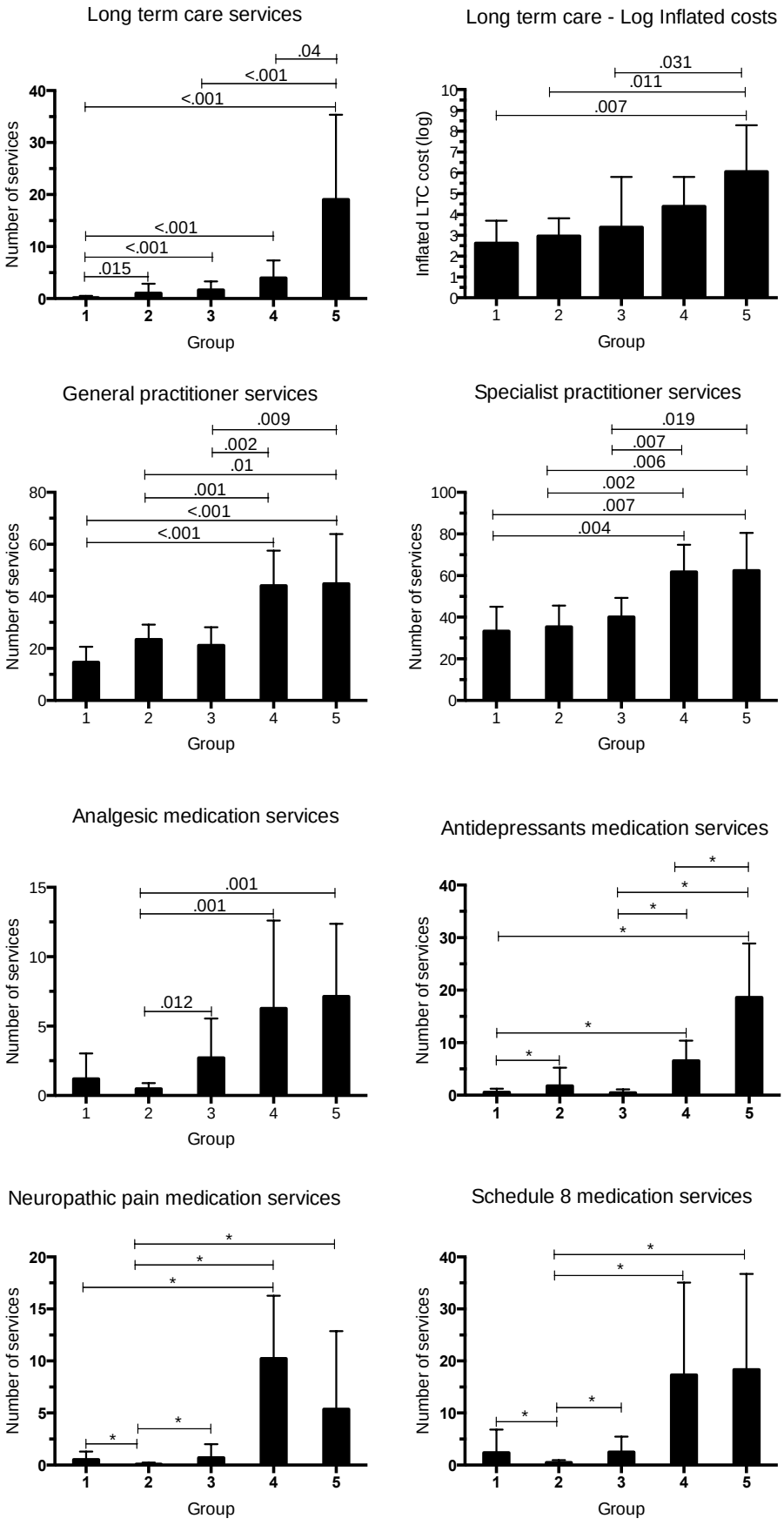

Figure 5. Association between group and specific service types

7. Summary of Findings

The current analysis comprised 162 individuals with TBI recruited in the post-acute period. Several significant relationships were found between group membership and background, community participation, and service utilisation. These findings provide further support for these groupings by demonstrating clinically meaningful patterns.

Importantly, the five groups did not differ in regards to the severity of injury, as assessed using both the duration of post-traumatic amnesia (PTA) and Glasgow Coma Score (GCS). This indicates that differences between community participation and service utilisation are more likely attributable, at least in part, to factors other than injury severity. The results also suggest that group 2 was younger and had fewer years of education. In turn, group 2 was more likely to live with their parents, rather than on their own or with a spouse. Interestingly, on the 12 dimensions group 2 also presented with greater cognitive deficits but otherwise average levels of strengths, environmental support, and physical functioning.

Group 1 displayed the best community participation outcomes, whereas group 4 and 5 the poorest outcomes. This aligns with the group scores on the 12 dimensions. That is, group 1 displayed intact cognitive functioning, above average strengths in self-perception as well as environmental supports and denied negative signs and symptoms. Conversely, groups 4 and 5 reported higher levels of symptoms and poorer levels of strengths. Group 5 also presented with poor performance validity, indicating potential lack of effort or other patterns of reporting not aligned with their neurological symptoms. In turn, compared to group 1, group 4 and 5 displayed poorer productivity, social outcomes, as well as overall community participation.

This pattern of results were maintained in regards to service utilisation. Group 1 displayed the least accrued costs and frequency of service utilisation. Conversely, groups 4 and 5 accrued greater overall costs and service utilisation. Groups 4 and 5 more frequently used long-term care, general, and specialist practitioner services. In addition, groups 4 and 5 more frequently used analgesic, antidepressant, neuropathic pain, and schedule 8 medications.

Overall, these findings highlight the presence of a good recovery group, group 1, as well as individuals, in groups 4 and 5, that are characterised by poorer outcomes and greater service utilisation. Because these groups did not differ on initial severity of injury these results indicate that other factors are related to longer term outcomes. These include the personal strengths of the individual, including self-esteem and resilience, as well as environmental supports.

This study is allowing us to identify some of the factors, other than injury severity, that contribute to poorer long-term levels of participation and greater costs to the TAC. These factors relate to persona resilience, psychological responses to injury and pain, the latter being associated with poorer outcomes. Conversely personal resilience, self-esteem, education, and economic and social supports are significant protective factors. The next step in this research will be for us to gather these measures early after in jury and examine their predictive validity. The ultimate aim of this study will be to provide TAC and the community of clinicians with an algorithm for identifying the likely trajectory of a given patient and an associated projected cost estimate.

8. References

1. Sherer M, Sander AM, Nick TG, Melguizo MS, Tulsky DS, Kisala P, Hanks R, Novack TA. Key dimensions of impairment, self-report, and environmental supports in persons with traumatic brain injury. Rehab Psychol. 2015;60(2):138-146.

2. Sherer M, Nick TG, Sander AM, Melguizo M, Hanks R, Novack TA, Tulsky D, Kisala P, Luo C, Tang X. Groupings of persons with traumatic brain injury: a new approach to classifying traumatic brain injury in the post-acute period. J Head Trauma Rehabil. 2015; Epub ahead of print.