Title: The effect of access to a designated interdisciplinary post-acute rehabilitation service on participant outcomes after brain injury

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ABSTRACT

Objective: This study aimed to determine the influence of participation in a designated acquired brain injury (ABI) transitional rehabilitation service (ABI TRS) on outcome, in the context of a historical comparison group (HIST). Design: A cohort study, with retrospective comparison. Participants: 187 persons with ABI. Measures: The Depression, Anxiety and Stress Scale (DASS-21), Mayo-Portland Adaptability Index (MPAI-4) and Sydney Psychosocial and Reintegration Scale (SPRS) were completed at discharge and 3-months after discharge. Participation in the ABI TRS involved interdisciplinary rehabilitation, 2–4 times per week, for 3-months after hospital discharge. Results: There was evidence that at 3-months, participants with ABI TRS showed stabilized psychological wellbeing, and improvements in MPAI-4 ability and participation scores; in addition to improvements in SPRS occupational activity and living skills scores. Conclusion: A designated ABI TRS may improve the transition from hospital to home, and could form an important part of the brain injury rehabilitation continuum, between the inpatient and community setting.

Keywords: Complex rehabilitation, service model, traumatic brain injury.
INTRODUCTION

Rehabilitation after acquired brain injury (ABI) requires interdisciplinary intervention (1). The neuropathological consequences of injury and resulting sequelae are broad, encompassing changes to physical, cognitive, behavioral, social and emotional functioning (2). Such changes in function have been shown to affect independence at home and in the community, return to work and driving, family relationships, and quality of life (1, 3). Loss of roles and valued activities after injury may further contribute to increased rates of psychological distress and social isolation (1, 4, 5). The complex nature of rehabilitation after ABI requires ongoing tailored support (1, 6, 7). As such, there is considerable risk of a delayed or impaired recovery when rehabilitation support and health service needs go unmet (1, 3, 8).

The transition from hospital into the community, encompassing pre-discharge planning and the first few months after discharge, has been identified as a critical phase of ABI rehabilitation (9-11). The duration of transition is not well defined within the literature (3, 9-12). For this article, transition will be defined as the first 3-months after hospital discharge. Access to coordinated, multidisciplinary health support, and the facilitation of opportunities to engage in meaningful activities are deemed necessary for successful transition (1, 8, 12). Participation in a designated transitional rehabilitation brain injury service—including individual and group therapy—may improve productivity and psychosocial function (13). It may also reduce the need for on-going care (13, 14), and be cost-saving to the tax payer (15). Accordingly, for people with ABI, access to a designated transition support service may be considered an essential part of the rehabilitation continuum (3, 14). Only a small number of studies have considered the impact of a designated rehabilitation service on participant outcomes in the context of a comparison group after brain injury (16-18).

Previous research has compared the effectiveness of an extended continuum of coordinated brain injury support to standard care (16, 17) or outpatient rehabilitation (18) after hospital discharge. Notably, these comparisons have not been exclusive to the transition period, with interventions ranging from 3-weeks (18) to ~6-months (17). While sample size (16, 18) and participant attrition (16) concerns of previous work have been highlighted (1), there is some evidence to suggest that participation in a designated rehabilitation service reduces disability (17), and improves participation (17), emotional
status (16), and motor and processing skills (18) after brain injury. Unfortunately, the transition period has not been considered in isolation, and only one study has examined the influence of access to a post-acute brain injury rehabilitation service in comparison to usual outpatient rehabilitation (18).

This study aimed to determine the influence of participation in a designated ABI Transitional Rehabilitation Service (TRS) on outcome, in the context of a historical comparison group, for whom outcome measures were collected before the introduction of a designated ABI TRS. We hypothesized that participation in a designated ABI TRS would improve psychological wellbeing, global function and social participation, compared to the historical group.

**METHODS**

*Acquired Brain Injury Transitional Rehabilitation Service*

In 2016 an ABI TRS was funded as a pilot project within the Division of Rehabilitation, at the Princess Alexandra Hospital, Brisbane, Australia. The first 2-weeks of the 3-month program involved collaborative pre-program planning with participants, family members and the inpatient rehabilitation team. The following 10-weeks consisted of intensive rehabilitation in the community (i.e., at home, or in a temporary residence). Participants with the ABI TRS were provided with interdisciplinary care, which involved case management and case coordination. Services included: medical (rehabilitation physician), clinical and neuropsychology, occupational therapy, speech pathology, physiotherapy, social work, and exercise physiology. Assessment needs were based on the International Classification of Functioning, Disability and Health (ICF) framework (19). Therapies were individualized, goal directed, and family oriented. There was a strong focus on maximizing functional independence, optimizing community reintegration and facilitating a return to meaningful activity (e.g., employment, volunteering, or study). Therapy was delivered 2–4 times per week, in individual and group sessions. Telehealth support was also provided. In addition to individualized and contextualized rehabilitation, vocational rehabilitation and specialist behavior support services were also provided.
Study design

Ethical approval was granted from the Metro South Hospital Health Service Research Governance Office (HREC/16/QPAH/812). Outcomes from participants with ABI TRS were compared to a historical comparison group (HIST), collected from the same tertiary hospital and the same ABI rehabilitation unit (3, 20). Importantly, the historical data were collected in the absence of a designated ABI TRS. HIST typically received specialist, centre-based outpatient ABI rehabilitation, consisting of 1–2 sessions per week for <3 months. Services included: occupational therapy, physiotherapy and/or speech pathology, under the direction of a rehabilitation physician. Outcome measures for both the ABI TRS and HIST were collected at matched time points: at hospital discharge (‘discharge’), and 3-months after discharge (‘3-months’). For ABI TRS, all questionnaire measures were completed by a clinician, in conjunction with the person with ABI. For the historical comparison, questionnaires were completed by the researcher, during a face-to-face or telephone interview.

Participants

The total study sample comprised 187 persons with ABI, including 63 participants with ABI TRS and 124 historical comparisons (Table 1). Participants with ABI TRS were consented between January 2017 and February 2018, on a consecutive discharge basis. Eligibility included: (1) adult-onset brain injury; (2) aged >16 years; (3) discharged from specialist brain injury inpatient rehabilitation; (4) clinically stable and safe for discharge to home/community; (5) ability to live in a home environment with or without assistance of family or other formal or informal supports (i.e., the ABI TRS did not provide lifestyle/disability support services); and (6) identified need for ongoing intensive rehabilitation from ≥2 therapies. Initial contact for study inclusion was made by a researcher. Written informed consent was provided by the person with ABI. In the instance that a participant did not have the cognitive capacity to consent (4/63 incidents)—as determined by the treating medical team—written consent, to use the individual’s data for the research, was gained through a substitute decision-maker declaration. Non-participation did not preclude service involvement.

Participants in the historical comparison group were recruited from the same tertiary hospital rehabilitation unit between February 2007 to June 2009. Inclusion criteria were: (1) diagnosis of an
ABI, as documented in a medical report; (2) aged 18–65 years; (3) discharged to the home/community environment (i.e., not to another facility, hospital, or residential care); (4) adequate cognitive skills to provide informed consent; and (5) adequate communication skills to participate in an interview with the researcher.

**Participant measures**

Psychological wellbeing was examined with the Depression, Anxiety and Stress Scale short form (DASS-21). The DASS-21 assesses symptoms of depression, anxiety, and stress. Each subscale comprises 7-items. Items are rated on a 4-point scale, where 0 indicates ‘did not apply to me at all’ and 3 ‘applied to me very much, or most of the time’ (21). Item responses were summed for each subscale, with higher scores indicating greater symptoms of distress. Depression scores were interpreted as: <9 normal, 10 mild, 14 moderate, 21 severe, and >28 extremely severe symptoms; anxiety scores: <7 normal, 8 mild, 10 moderate, 15 severe, >20 extremely severe; and stress scores: <14 normal, 15 mild, 19 moderate, 26 severe and >34 extremely severe (21). The DASS-21 has demonstrated validity for the states of depression (Cronbach’s alpha $\alpha = .93$), anxiety ($\alpha = .85$), and stress ($\alpha = .90$) in brain injury (22).

Global function was examined using the Mayo-Portland Adaptability Inventory (MPAI-4) (23). The MPAI-4 captures interference with daily or valued activities in three domains: ability, adjustment, and participation (23). The questionnaire comprises 30-items, with each item rated on a 5-point scale ranging from 0 ‘no problem’ to 4 ‘severe problem’. Subscale responses were summed, with higher scores indicating greater problems. Raw scores were standardized (T-scores). The MPAI-4 has shown high psychometric validity ($\alpha = .89$) (24).

Social participation was assessed with the 5-point Sydney Psychosocial Reintegration Scale (SPRS-2). The SPRS-2 examines participation in three domains: occupational activity, interpersonal relationships, and independent living skills (25). Higher scores indicate less disturbance compared to pre-injury (25). For HIST, social participation was measured using the original 7-point SPRS. Before analysis, data were transformed using the minimum and maximum possible score on each respective scale (see data analysis). The SPRS-2 shares a strong association with the original 7-point SPRS
Spearman’s $r = .98$), and high inter-rater (Intraclass correlation [ICC] = .94) and test-retest (ICC = .91) reliability in a brain injury population (25).

The functional consequences of impairments, evidenced by level of care and support required, were measured with the Care and Needs Scale (CANS) (26). Ratings from section two were utilized—i.e., the length of time a person with ABI can be left alone. The length of time an individual with ABI was able to be left alone was rated on a 0 ‘can live in the community, totally independently’ to 7 ‘cannot be left alone’ scale (26). Thus, higher category ratings indicate a greater intensity of support needs. The CANS has demonstrated excellent interrater reliability within (ICC = .95) and between (ICC = .96) health disciplines (27). The CANS was not collected for HIST.

Perceived health status was assessed using the EuroQol visual analogue scale (EQ-VAS) (28). Persons with ABI were asked to rate their health from 0 ‘worst health imaginable’ to 100 ‘best health imaginable’ (28). EuroQol-5D values were not compared due to collection on different scales (HIST 3-level, ABI TRS 5-level); however, descriptive summaries are provided in Supplemental 1.

**Data analysis**

DASS-21, MPAI-4, SPRS and EQ-VAS were modelled with Bayesian hierarchical regression with a zero- and/or one-inflated beta (ZOIB) response distribution, using the ‘zoib’ package (29) in R (Version 3.5.0). Before analysis, data were transformed to the (0, 1) interval using the equation: $y' = (y - a)/(b - a)$, where ‘$a$’ is the minimum possible questionnaire score, ‘$b$’ the maximum possible score, and ‘$y$’ the observed score (30). The ZOIB model is highly suited for the analysis of bounded questionnaire data (30). Based on a piecewise distribution, the model accounts for probability mass at exactly 0 (i.e., $y = 0$, minimum possible questionnaire score) and exactly 1 (i.e., $y = 1$, maximum possible score), and the probability density within 0 and 1 (29, 30). Estimating the probability of minimum ($y = 0$) and maximum ($y = 1$) scores helps prevent the biased estimation of scores that fall between 0 and 1 (29).

All models included participant ID as a random effect variable. Candidate models considered adjustment for injury type (i.e., non-traumatic or traumatic brain injury), length of hospital stay (LOS), and age and gender, with the final model chosen based on the smallest Deviance Information Criteria
value. Two independent Markov chain Monte Carlo (MCMC) chains were run per model, each with 10,200 MCMC iterations, including a 200-iteration burn-in, and thinned by a factor of 50. A Normal (mean 0, precision 0.001) prior distribution was utilized for each regression coefficient (β), and a Uniform (mean 0, SD 20) prior for the SD of the random effect. Posterior estimates are reported as the mean (or mean difference [MD]) and 95% credible interval (CI). Cohen’s d was calculated using the denominator: \( \sqrt{\sigma^2_{dkl}} \), where ‘\( \sigma^2_{dkl} \)’ is the variance on the difference between groups or time points ‘k’ and ‘l’ (31). Cohens d values were interpreted as small 0.20–0.49, medium 0.5–0.79, and large \( \geq 0.80 \) (31). When statistical differences were observed at discharge, the within-group change from discharge to 3-months was compared between conditions, via the generation of a posterior distribution. When time, group or time x group effects were observed for \( y = 0 \) (i.e., a minimum score on the scale) and \( y = 1 \) (i.e., a maximum score), the probability has been reported.

CANS responses were modelled using multinomial logistic regression. A random intercept was included for each participant ID. A Normal (mean 0, precision 0.001) prior distribution was utilized for each β, and a Gamma (shape 0.01, scale 0.01) prior distribution for the precision of the random effect. Posterior estimates were based on 51,000 MCMC iterations, with a 1,000 iteration burn-in and thinned by a factor of 10. Results for CANS are reported as the median (95% CI) probability. Statistical differences between probabilities (within a CANS category) were determined by computing a posterior distribution of the difference between time points. For all models, the convergence of MCMC to the posterior was assessed via trace plots, and posterior predictive checks were performed to assess the suitability of the chosen models. When the 95% CI of a β or MD did not include zero, it was concluded that there was evidence of a statistical effect or difference.

RESULTS

Participants missing more than one item on a subscale were coded as missing for that outcome measure. Missing responses for participants with ABI TRS were: DASS-21 depression, anxiety and stress 10.3%; MPAI-4 ability, adjustment, participation 5.6%; SPRS occupational activity, interpersonal relationships and living skills 5.6%; CANS 4.8%; and EQ-VAS 5.6%. HIST: depression,
anxiety and stress 10.1%; ability 9.3%, adjustment 10.1%, participation 9.7%; occupational activity, interpersonal relationships and living skills 9.3%; and EQ-VAS 9.7%. No values were imputed for missing observations.

**Depression, anxiety and stress**

The final models for DASS-21 subscales are shown in Table 2. Mean depression scores for HIST were considered normal at discharge and mild at 3-months; and for ABI TRS mild at both time points (Figure 1A). Discharge depression scores were statistically higher for ABI TRS compared to HIST (MD [95% CI] = 4 [1, 7]; $d = 2.68$; Figure 1A). The change in scores from discharge to 3-months was statistically different between groups (MD = -3.8 [-7.2, -0.2]; $d = -2.15$; Figure 1A).

Mean anxiety scores were in the normal range for HIST at both time points and for participants with ABI TRS at 3-months; and in the mild range for those with ABI TRS at discharge (Figure 1B). Discharge anxiety scores were statistically higher for ABI TRS compared to HIST (MD [95% CI] = 3 [1, 5]; $d = 2.43$; Figure 1B). The change in anxiety scores from discharge to 3-months was statistically different between groups (MD = -2.7 [-5.3, -0.2]; $d = -2.08$), with a favorable change for participants with ABI TRS, but not HIST (Figure 1B).

Mean stress scores were considered normal for HIST and ABI TRS at both time points (Figure 1C). Discharge stress scores were statistically higher for TRS compared to HIST (MD [95% CI] = 2.8 [0.3, 5.5]; $d = 2.07$; Figure 1C). The change in scores from discharge to 3-months was statistically different between HIST and ABI TRS (MD = -4.6 [-7.7, -1.7]; $d = -3.08$), with a favorable change for participants with ABI TRS, but not HIST (Figure 1C).

**Global function**

Table 2 shows the final models for MPAI-4 ability, adjustment and participation. Discharge ability scores were statistically higher for participants with ABI TRS compared to HIST (MD [95% CI] = 10 [7, 14]; $d = 5.57$; Figure 1D). The change in ability scores from discharge to 3-months was statistically different between groups (MD = -7 [-12, -3]; $d = -3.34$; Figure 1D), with a favorable change for participants with ABI TRS.
Adjustment scores were statistically higher for participants with ABI TRS compared to HIST at both discharge (MD [95% CI] = 11 [5, 15]; d = 4.39; Figure 1E) and 3-months (MD [95% CI] = 6 [2, 9]; d = 3.62; Figure 1E). The change in adjustment scores from discharge to 3-months was statistically different between groups (MD = -5 [-7, -2]; d = -3.85; Figure 1E).

Participation scores were statistically higher at discharge for participants with ABI TRS compared to HIST (MD [95% CI] = 4 [1, 7]; d = 2.75; Figure 1F). The change in participation scores from discharge to 3-months was statistically different between groups (MD = -5 [-9, -1]; d = -2.81); with a more favorable change for participants with ABI TRS compared to HIST (Figure 1F).

Social participation

The final models for SPRS subscales are shown in Table 3. Differences in SPRS are reported on the 0–1 interval. Occupational activity scores were statistically lower for participants with ABI TRS compared to HIST at discharge (MD [95% CI] = -0.5 [-0.5, -0.4]) and 3-months (MD = -0.3 [-0.4, -0.2]). The change in scores from discharge to 3-months was statistically different between groups (MD = 0.20 [0.13, 0.26]; d = 6.07), with a favorable change for participants with ABI TRS (Table 4). The probability of rating the highest occupational activity category at both time points was greater for HIST (.38 and .27, respectively) compared to ABI TRS (<.001 and .012, respectively).

Interpersonal relationship scores were statistically higher for HIST at both time points (Table 4). The change in interpersonal relationship scores from discharge to 3-months was not statistically different between groups (d = -0.07). The probability of rating the highest interpersonal relationships category increased at 3-months compared to discharge for both groups (HIST = .09 to .18; ABI TRS = .10 to .20).

Living skills scores were statistically lower for participants with ABI TRS compared to HIST at both discharge (MD [95% CI] = -0.24 [-0.30, -0.18]; Table 4) and 3-months (MD = -0.07 [-0.12 - 0.03]; Table 4). The change in scores from discharge to 3-months was different between groups (MD = 0.16 [0.11, 0.22]; d = 5.33), with participants with ABI TRS showing a greater improvement (Table 4). The probability of rating the highest living skills category at both time points was greater for HIST (.07 and .20, respectively) compared to ABI TRS (<.001 and .03, respectively).
**Care and needs**

There was evidence of a left-ward shift in CANS ratings at 3-months compared to discharge (Figure 2), with a decrease in ratings in the higher CANS categories—and an increase in ratings in the lower categories—indicating lower support requirements at 3-months compared to discharge.

**Perceived health status**

Table 3 shows the final model for EQ-VAS. Discharge and 3-month EQ-VAS scores for HIST were: 72 [69, 75] and 75 [72, 78], respectively. For participants with ABI TRS, discharge and 3-months scores were: 70 [66, 74], and 73 [69, 77], respectively. EQ-VAS ratings were not statistically different between groups at either time point.

**DISCUSSION**

This study aimed to determine the effect of participation in a designated ABI TRS on outcome, compared to a historical dataset, collected in the absence of a designated service. It was hypothesized that participation in the ABI TRS would improve psychological wellbeing, global function and social participation compared to HIST. The results suggest that participation in an ABI TRS stabilized participants’ psychological wellbeing (Figure 1A and 1C), and improved aspects of global function (Figure 1D and 1F) and social participation (Table 4) compared to HIST. These findings support the hypotheses and suggest that access to a designated ABI TRS improves the transition from hospital to home, and provides an important link in the brain injury rehabilitation continuum.

Participants with ABI TRS scored statistically worse at discharge for depression, anxiety and stress compared to HIST. However, at 3-months, depression scores were maintained (Figure 1A) and mean scores for anxiety indicated a clinical improvement in symptoms, from mild to normal (Figure 1B). In contrast, HIST demonstrated an increase (worsening) in depression and anxiety scores at 3-months compared to discharge (Figure 1A–1C). Differences at discharge may be related to the shorter LOS observed for participants with ABI TRS, and the nature of injuries (Table 1). Alternatively, this could be the result of in-reach rehabilitation from participation in the ABI TRS. The in-reach may have
helped participants prepare for the transition from hospital to home, such that they developed more realistic expectations of the potential difficulties, and associated distress, that they would face upon discharge and community reintegration. Mean HIST depression scores increased from normal to mild symptoms. Such a change may alter the intensity of an individual’s treatment needs (32). In support of our findings, previous studies have observed no within-group change in psychological wellbeing after participation in a designated community-based brain injury rehabilitation program (16, 17).

Therapies that encourage meaningful activity engagement, and aim to minimize psychosocial distress are critical components for driving positive changes in participation after ABI (33-35). The person-centered and goal driven rehabilitation delivered by the ABI TRS targeted functional independence, community reintegration, and the return to meaningful occupation (e.g., employment, volunteering or study). Further, the incorporation of family orientated treatment and specialist behavior support may have assisted in preventing a decline in psychosocial wellbeing (13, 32, 36). A maintenance of psychological status was observed at 3-months compared to discharge for participants with ABI TRS (Figure 1A–1C), in addition to improvements in psychosocial functioning (Figure 1; Table 4). While it is challenging to delineate the precise mechanism(s) responsible for these findings, the model of care (i.e., interdisciplinary, person-centered, goal driven, family orientated, specialist behavior, and vocational rehabilitation) used by the ABI TRS may have positively contributed. In agreement with others, all MPAI-4 subscales (37), and SPRS living skills (38) required adjustment for LOS. This may further highlight the complexity of identifying the precise factor, or factors, modulating our psychological wellbeing and psychosocial functioning results.

In support of the benefits of participation in a designated ABI TRS, positive changes in CANS ratings were observed at 3-months compared to discharge. At 3-months, participants demonstrated a reduction in requirement for intensity of support needs, particularly in the ‘up to 11 hours per day’ and ‘24 hours per day’ categories (Figure 2). While high support needs do not necessarily preclude the adoption of an active life or a valued life role (39), these support needs improvements may positively influence the adoption of a valued life role. Improved scores of global function (Figure 1D–1F) and participation (Table 4) at this same time point may partly explain improvements in the CANS (40). Support needs were not assessed by HIST, meaning comparison cannot be made. Therefore, our results
should be interpreted with caution, as other factors, such as time since injury, and natural recovery, may explain our positive findings for this outcome measure.

At discharge, participants with ABI TRS scored worse on measures of psychosocial wellbeing (Figure 1A–1C), global function (Figure 1D–1F), and social participation (occupational activity and living skills; Table 4) compared to HIST. Several factors may explain these findings. Injury inclusion criteria differences between the data collections indicate the ABI TRS was more inclusive. Greater disability after brain injury may explain the psychological wellbeing and psychosocial functioning scores (33-35, 41). Historical changes in rehabilitation services over time may have also contributed to our observations. LOS was shorter for participants with ABI TRS. There may be many clinical and non-clinical factors involved with a shorter LOS (e.g., desire to reduce hospital stay, and/or a shift in focus from hospital to community rehabilitation). It is possible that a designated ABI TRS may have altered the available discharge pathways, by providing the necessary support to families to both facilitate and encourage the earlier discharge of persons with ABI.

This study is not without limitation. While HIST enabled comparison to outcomes when no designated service was in operation, a number of factors may be different between the two time periods (i.e., 2007–2009 versus 2017–2018). For example, possible differences in the health system, medical advancements, and expertise of rehabilitation practitioners require consideration. A measure of self-awareness was not included by either group. An increased ability to recognize impairments, mediated by changes in self-awareness (42), may affect, and possibly explain participant outcomes (42-44). Future research should consider the long-term impact of participation in a designated ABI TRS, the effect on the experiences of caregivers, and the economic benefits of a designated ABI TRS.

CONCLUSION

Participation in ABI TRS stabilized psychological wellbeing, and improvements in scores of global function and social participation compared to HIST. There was also evidence of a reduction in the intensity of support needs required, though comparison with HIST was not possible. These findings suggest that a designated ABI TRS could provide an important link in the brain injury rehabilitation continuum and may improve the transition from hospital to home.
REFERENCES


# TABLES

## Table 1.
Participant demographic and injury characteristics.

<table>
<thead>
<tr>
<th></th>
<th>HIST (n = 124)</th>
<th>ABI TRS (n = 63)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at injury (years), median (IQR)</td>
<td>38 (26–47)</td>
<td>47 (23–59)</td>
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<tr>
<td>Gender</td>
<td></td>
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</tr>
<tr>
<td>Female</td>
<td>28.2%</td>
<td>23.8%</td>
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<tr>
<td>Male</td>
<td>71.8%</td>
<td>76.2%</td>
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<tr>
<td>Injury type</td>
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<tr>
<td>Non-traumatic</td>
<td>28.2%</td>
<td>50.1%</td>
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<tr>
<td>Traumatic</td>
<td>71.8%</td>
<td>49.9%</td>
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<tr>
<td>Duration of PTA (days), median (IQR)</td>
<td>33 (22–62)</td>
<td>34 (26–52)</td>
</tr>
<tr>
<td>Glasgow Coma Scale, median (IQR)</td>
<td>8 (4–12)</td>
<td>8 (4–13)</td>
</tr>
<tr>
<td>Length of hospital stay (days), median (IQR)</td>
<td>88 (62–147)</td>
<td>81 (59–117)</td>
</tr>
<tr>
<td>Type of diagnosis</td>
<td></td>
<td></td>
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<tr>
<td>Cerebrovascular accident</td>
<td>7.3%</td>
<td>19.4%</td>
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<tr>
<td>Subarachnoid hemorrhage/aneurysm</td>
<td>11.3%</td>
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<td>Subacute/chronic subdural hematoma</td>
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<td>4.8%</td>
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<td>Hypoxia</td>
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</tr>
<tr>
<td>Trauma</td>
<td>71.8%</td>
<td>48.4%</td>
</tr>
<tr>
<td>Other</td>
<td>6.5%</td>
<td>16.1%</td>
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</table>

*Note.* Type of diagnosis was unknown for one participant with ABI TRS.

ABI TRS = Acquired Brain Injury Rehabilitation Service  
HIST = Historical comparison group  
IQR = Interquartile range  
PTA = Post traumatic amnesia
Table 2. Posterior mean [95% credible interval] parameter estimates from the final Bayesian zero and/or one inflated beta distribution model for Depression Anxiety and Stress Scale (DASS-21) depression, anxiety and stress and Mayo-Portland Adaptability Inventory (MPAI-4) ability, adjustment and participation.

<table>
<thead>
<tr>
<th>Model component</th>
<th>Parameter</th>
<th>DASS-21 depression</th>
<th>DASS-21 anxiety</th>
<th>DASS-21 stress</th>
<th>MPAI-4 ability</th>
<th>MPAI-4 adjustment</th>
<th>MPAI-4 participation</th>
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</thead>
<tbody>
<tr>
<td>logit(mean)</td>
<td>Intercept</td>
<td>-1.679 [-1.951, -1.411]*</td>
<td>-1.890 [-2.098, -1.658]*</td>
<td>-1.471 [-1.709, -1.257]*</td>
<td>-0.842 [-0.953, -0.724]*</td>
<td>-0.904 [-1.284, -0.531]*</td>
<td>-0.020 [-0.144, 0.178]</td>
</tr>
<tr>
<td>Length of stay</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.002 [0.001, 0.003]*</td>
<td>0.0099 [0.0002, 0.0016]*</td>
</tr>
<tr>
<td>as.factor(injury type)—traumatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.241 [-0.373, -0.111]*</td>
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<tr>
<td>as.factor(time)—3-months</td>
<td></td>
<td>0.572 [0.296, 0.870]*</td>
<td>0.219 [-0.036, 0.516]</td>
<td>0.398 [0.143, 0.639]*</td>
<td>0.072 [-0.029, 0.191]</td>
<td>3.444 [0.151, 0.559]*</td>
<td>-0.073 [-0.198, 0.049]</td>
</tr>
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<td>as.factor(group)—ABI TRS</td>
<td></td>
<td>0.581 [0.175, 0.992]*</td>
<td>0.463 [0.115, 0.819]*</td>
<td>0.390 [0.042, 0.753]*</td>
<td>0.408 [0.268, 0.733]*</td>
<td>0.482 [0.230, 0.418]*</td>
<td>0.247 [0.074, 0.302]</td>
</tr>
<tr>
<td>as.factor(time)—3-months x as.factor(group)—ABI TRS</td>
<td></td>
<td>-0.574 [-1.041, -0.097]*</td>
<td>-0.489 [-0.932, -0.038]*</td>
<td>-0.638 [-1.029, -0.233]*</td>
<td>-0.286 [-0.462, -0.130]*</td>
<td>-0.239 [-0.380, -0.100]*</td>
<td>-0.302 [-0.520, -0.085]*</td>
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<tr>
<td>logit(Pr(y = 0))</td>
<td>Intercept</td>
<td>-0.607 [-0.823, -0.375]*</td>
<td>-0.355 [-0.570, -0.124]*</td>
<td>-1.158 [-1.416, -0.941]*</td>
<td>-6.428 [-9.467, -4.610]*</td>
<td>-5.427 [-7.303, -4.015]*</td>
<td>-6.356 [-9.141, -4.497]*</td>
</tr>
<tr>
<td>logit(Pr(y = 1))</td>
<td>Intercept</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-6.448 [-9.782, -4.633]*</td>
</tr>
<tr>
<td></td>
<td>σ</td>
<td>0.645 [0.367, 0.982]*</td>
<td>0.406 [0.166, 0.643]*</td>
<td>0.606 [0.349, 0.896]*</td>
<td>0.065 [0.027, 0.106]*</td>
<td>0.079 [0.052, 0.114]*</td>
<td>0.104 [0.057, 0.160]*</td>
</tr>
</tbody>
</table>

Note. Candidate models considered adjustment for injury type (i.e., non-traumatic or traumatic), length of stay, age and gender; with the final model chosen based on the smallest Deviance Information Criteria value.

ABI TRS = Acquired Brain Injury Rehabilitation Service.
Pr = Probability.
q = regression coefficient in the linear predictor for the sum of the two shape parameters in the beta distribution.
σ = posterior mean of the variance of the random effect (i.e., participant ID).
* indicates a statistically important effect (i.e., when the 95% CI does not include zero).
Table 3.
Posterior mean [95% credible interval] parameter estimates from the final Bayesian zero and/or one inflated beta distribution model for the Sydney Psychosocial Reintegration Scale (SPRS) subscales interpersonal relationships, and independent living skills, and the EuroQol visual analogue scale (EQ-VAS).

<table>
<thead>
<tr>
<th>Model component</th>
<th>Parameter</th>
<th>SPRS occupational activity</th>
<th>SPRS interpersonal relationships</th>
<th>SPRS independent living skills</th>
<th>EQ-VAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>logit(mean)</td>
<td>Intercept</td>
<td>1.772 [1.530, 1.996]*</td>
<td>1.367 [1.172, 1.553]*</td>
<td>1.757 [1.495, 2.001]*</td>
<td>0.943 [0.796, 1.090]*</td>
</tr>
<tr>
<td></td>
<td>Length of stay</td>
<td>–</td>
<td>–</td>
<td>-0.004 [-0.005, -0.002]*</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>as.factor(time) — 3-months</td>
<td>-0.303 [-0.533, -0.028]*</td>
<td>-0.008 [-0.177, 0.159]</td>
<td>0.033 [-0.165, 0.221]</td>
<td>0.142 [0.002, 0.275]*</td>
</tr>
<tr>
<td></td>
<td>as.factor(group) — ABI TRS</td>
<td>-2.303 [-2.621, -1.965]*</td>
<td>-0.614 [-0.881, -0.348]*</td>
<td>-1.292 [-1.580, 1.010]</td>
<td>-0.097 [-0.323, 0.119]</td>
</tr>
<tr>
<td></td>
<td>as.factor(time) — 3-months x as.factor(group) — ABI TRS</td>
<td>0.952 [0.617, 1.265]*</td>
<td>–</td>
<td>0.786 [0.452, 1.086]*</td>
<td>–</td>
</tr>
<tr>
<td>logit(Pr(y = 0))</td>
<td>Intercept</td>
<td>-36.214 [-74.531, -6.433]*</td>
<td>–</td>
<td>–</td>
<td>-28.743 [-74.298, -7.128]*</td>
</tr>
<tr>
<td></td>
<td>as.factor(time) — 3-months</td>
<td>-2.187 [-43.804, 45.303]</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>as.factor(group) — ABI TRS</td>
<td>34.134 [4.319, 72.704]*</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>as.factor(time) — 3-months x as.factor(group) — ABI TRS</td>
<td>1.551 [-46.014, 43.620]</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>logit(Pr(y = 1))</td>
<td>Intercept</td>
<td>-0.467 [-0.843, -0.080]*</td>
<td>-2.361 [-3.002, -1.831]*</td>
<td>-2.555 [-3.231, -1.902]*</td>
<td>-3.427 [-3.942, -2.835]*</td>
</tr>
<tr>
<td></td>
<td>as.factor(time) — 3-months</td>
<td>-0.487 [-1.033, 0.063]</td>
<td>0.853 [0.209, 1.530]*</td>
<td>1.142 [0.331, 1.933]*</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>as.factor(group) — ABI TRS</td>
<td>-26.884 [-74.537, -3.817]*</td>
<td>0.117 [-0.494, 0.758]</td>
<td>-24.408 [-75.332, -2.929]*</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>as.factor(time) — 3-months x as.factor(group) — ABI TRS</td>
<td>23.292 [0.269, 71.672]*</td>
<td>–</td>
<td>22.236 [0.334, 73.878]*</td>
<td>–</td>
</tr>
<tr>
<td>σ</td>
<td></td>
<td>0.530 [0.323, 0.780]*</td>
<td>0.441 [0.286, 0.624]*</td>
<td>0.323 [0.176, 0.494]*</td>
<td>0.265 [0.111, 0.419]*</td>
</tr>
</tbody>
</table>

Note. Candidate models considered adjustment for injury type (i.e., non-traumatic or traumatic), length of stay, age and gender; with the final model chosen based on the smallest Deviance Information Criteria value.

ABI TRS = Acquired Brain Injury Rehabilitation Service.

Pr = Probability.

q = regression coefficient in the linear predictor for the sum of the two shape parameters in the beta distribution.

σ = posterior mean of the variance of the random effect (i.e., participant ID).

* indicates a statistically important effect (i.e., when the 95% CI does not include zero).
Table 4.

Posterior mean [95% credible interval] Sydney Psychosocial Reintegration Scores (SPRS) for the historical comparison (HIST) and Acquired Brain Injury Transitional Rehabilitation Service (ABI TRS) groups.

<table>
<thead>
<tr>
<th>SPRS</th>
<th>HIST (n = 124)</th>
<th>ABI TRS (n = 63)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Discharge</td>
<td>3-months</td>
</tr>
<tr>
<td>Occupational activity</td>
<td>0.85 [0.82, 0.88]</td>
<td>0.81 [0.78, 0.85]</td>
</tr>
<tr>
<td>Interpersonal relationships</td>
<td>0.80 [0.76, 0.83]</td>
<td>0.80 [0.76, 0.83]</td>
</tr>
<tr>
<td>Independent living skills</td>
<td>0.85 [0.82, 0.88]</td>
<td>0.86 [0.82, 0.89]</td>
</tr>
</tbody>
</table>

Note. The historical comparison group used the 7-point SPRS, and the Acquired Brain Injury Transitional Rehabilitation Service group the 5-point SPRS. Data were transformed and modelled on the 0–1 beta interval.

† Ratings shown on their original scales, i.e., HIST 0–24 and ABI TRS 0–16, respectively.
‡ Indicates statistically different to HIST at the same time point.
‡ Indicates the change from discharge to 3-months was statistically different between-groups.
FIGURE CAPTIONS

**Figure 1.** Posterior mean (95% credible interval) for subscales from the Depression, Anxiety and Stress Scale (DASS-21) short form, and Mayo-Portland Adaptability Inventory (MPAI-4) questionnaire at discharge, and 3-months after discharge. DASS-21 depression (A), anxiety (B), and stress (C) scores; and MPAI-4 T-scores for ability (D), adjustment (E), and participation (F). HIST = Historical comparison group, ABI TRS = Acquired Brain Injury Transitional Rehabilitation Service group, † indicates statistically different to HIST at the same time point, ‡ indicates the change from discharge to 3-months was statistically different between-groups.

**Figure 2.** Median (95% credible interval) posterior probability of Care and Needs Scale (CANS) category ratings at discharge, and 3-months after discharge, for the Acquired Brain Injury Transitional Rehabilitation Service group (ABI TRS). Posterior probabilities (across all categories) sum to one for each time point. * indicates statistically different between time points, within a category. Note, the CANS was not collected by the historical comparison group.