Demographics of traumatic brain injury and outcomes of continuous chain of early rehabilitation in Singapore

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Abstract

Background: Evidence shows that early initiation of a continuous chain of rehabilitation is associated with better functional outcomes in traumatic brain injured patients. The Department of Rehabilitation Medicine initiated early screening and review of patients with all traumatic brain injury (TBI) severity within 72 hours of acute admission, followed by direct transfer of suitable patients to acute inpatient rehabilitation (AIR).

Objectives: This study aims to document the demographics and clinical characteristics of all TBI patients admitted to the local acute hospital; determine the characteristics of patients with TBI who are directly transferred to AIR following early screening and review; and determine clinical predictors affecting functional outcomes of patients of all TBI severity.

Methods: A total of 491 patients were screened and reviewed; 116 patients were directly transferred to AIR.

Results: The median age of the screened cohort was 67.0 years (interquartile range 50.0–77.0 years). Falls were the leading mechanism of TBI. Infection (odds ratio (OR)=2.95, 95% confidence interval (CI) 1.59–5.49) and neurosurgical intervention (OR=2.18, 95% CI 1.24–3.81) increased the odds of transfer to AIR. The Functional Independence Measure (FIM) gain after receiving AIR was significant \( p < 0.001 \). Increased age, complications, high motor admission FIM (AFIM) and long rehabilitation length of stay (RLOS) were negatively associated with FIM gain and FIM efficiency.

Conclusions: Our study demonstrated that falls were the leading mechanism of TBI, with the majority of patients being older. Infection and neurosurgical intervention increased the likelihood of transfer to AIR. There was functional improvement after AIR. Age, complications, motor AFIM and RLOS were negatively associated with FIM gain and FIM efficiency. Further local research is warranted to confirm these findings.

Keywords

Traumatic brain injury, functional outcomes, gain, efficiency, early rehabilitation
The objectives of the study are: (a) to document the demographics and clinical characteristics of patients of all TBI severity admitted to the acute hospital; (b) to determine the characteristics of patients with TBI who are directly transferred to the AIR unit, following early screening and review; and (c) to determine the clinical predictors affecting functional outcomes of patients of all TBI severity.

**Methods**

**Participants**

A total of 491 patients with head trauma were screened and reviewed between 1 November 2010 and 30 October 2012 by the on-duty rehabilitation medicine specialist within 72 hours of admission to the Department of Neurosurgery (NES) ward in an acute tertiary hospital. Five rehabilitation medicine specialists were rostered to perform the screening and review at that time.

Patients received twice weekly multidisciplinary reviews and approximately half an hour to two hours of therapy per day, five days a week, depending on their medical stability and rehabilitation needs, while they were acutely admitted under NES. The multidisciplinary team consisted of a rehabilitation medicine specialist, nurse, physiotherapist, occupational therapist, speech therapist, dietician and medical social worker. Patients who fulfilled the following criteria were then recommended and transferred to AIR: (a) presence of impairments or disabilities which could benefit from a comprehensive inpatient rehabilitation programme, (b) potential to participate in a goal-oriented rehabilitation programme and (c) medical stability to participate in a rehabilitation setting. These criteria were based on our department’s general criteria for admission to AIR which were similar to other clinical practice guidelines for the rehabilitation of TBI patients.

A total of 116 patients were directly transferred to AIR (continuous chain of early rehabilitation).

**Procedures**

This was a retrospective study of the Department of Rehabilitation Medicine Traumatic Brain Injury Registry and Database. Approval and waiver of consent was obtained from the Institutional Review Board. The principal investigator and co-investigators reviewed the medical records.

The data collected included demographic variables consisting of age, sex, and race; acute clinical characteristics, including mechanism of injury, Glasgow Coma Scale (GCS) upon admission, neuroimaging findings and neurosurgical interventions; complications, including nosocomial infections, post-traumatic seizures, deep-vein thrombosis (DVT), dysautonomia and the need for tracheostomy; acute LOS (ALOS) and the discharge disposition; rehabilitation outcomes, including the Functional Independence Measure (FIM) and Rancho Los Amigos Scale-Revised (RLAS-R) scale. For patients transferred directly to AIR, rehabilitation LOS (RLOS), FIM gain (discharge FIM (DFIM)–admission FIM (AFIM)) which measures functional improvement and FIM efficiency (FIM gain/RLOS) which measures rate of functional improvement were collected.

**Measures**

The FIM is a standardised functional outcome measure commonly used in rehabilitation, and its validity in patients with TBI is well supported. It consists of 13 motor and five cognitive items. The scores range from 1 (totally dependent) to 7 (totally independent) for each item, with a maximum score of 126. The FIM was recorded during the first review within 72 hours of admission for all screened patients.

The RLAS-R is a standardised 10-level descriptive scale which describes the cognitive and behavioural patterns in brain-injured patients as they recover. It facilitates communication among health-care professionals and is useful in treatment planning and cognitive recovery tracking. The RLAS-R was recorded during the first review.

The injury mechanisms were classified as falls, road traffic accidents (RTA), assault, sports and other. Falls were categorised into mechanical (e.g. slipped and fell on wet surface), non-mechanical (e.g. fell as a result of muscle weakness) and unattended falls. The term ‘mechanical fall’ was based on the description recorded by the admitting doctors, which was associated with a slip or trip, implying an external mechanical force or object had caused the fall. Sports were further differentiated into non-contact versus contact sports (e.g. rugby, boxing, martial arts and soccer).

The GCS was documented on admission and was used to classify the severity of TBI into mild (GCS 13–15), moderate (9–12) and severe (GCS 3–8) categories.

The types of head injury were determined according to predominant neuroimaging findings and were categorised into isolated subdural haematoma (SDH), isolated subarachnoid haemorrhage, isolated extradural haemorrhage, isolated contusion, isolated intracerebral haemorrhage, mixed haemorrhage (combination of any of the above haemorrhages), other (face or skull fractures and/or scalp haematoma) and concussion. Concussion is usually associated with normal structural neuroimaging. It is defined as ‘biomechanical injury leading to altered brain function and its sequelae include somatic, cognitive and emotional disturbances, which are usually most severe within the first week post-injury’.

Nosocomial infections and DVT were recorded based on investigations; post-traumatic seizures and dysautonomia were recorded based on medical records; tracheostomy and neurosurgical interventions were recorded based on surgical records.

The ALOS for all screened patients was defined as the time from acute NES admission to direct discharge from NES. For patients who were directly transferred to AIR, the RLOS was defined as the time from admission to AIR to discharge.

**Statistical analysis**

Descriptive statistics for continuous data are presented as percentages or as the median with interquartile (IQR) range. For normally distributed data, an independent t-test and one-way analysis of variance were used to assess differences in group means for continuous variables, while Fisher’s exact test and the chi-square test were used to examine the differences for categorical variables. For non-normally distributed data, the Mann–Whitney U-test or Kruskal–Wallis H-test was used instead.
Variables which were clinically relevant for transfer to AIR, with \( p < 0.10 \) in the univariate analyses, were selected for entry into a multivariate logistic regression model to determine the variables associated with discharge outcome of the early screened patients (directly discharged from the acute NES ward or directly transferred to AIR). \(^{20}\)

Wilcoxon’s signed rank test was used to compare AFIM and discharge DFIM within the AIR group. Age was divided into \(<30\) years, \(30–59\) years and \(\geq 60\) years to determine whether there were differences in FIM gain and FIM efficiency among the young, middle-aged and older groups. Multiple linear regression analyses were performed to identify the independent clinical variables associated with FIM gain and FIM efficiency.

Significance was determined at \( p \leq 0.05 \), and statistical analysis was done using IBM SPSS Statistics v 25 (IBM Corp., Armonk, NY).

**Results**

**Demographics and clinical characteristics of the early screened group**

The median age of the patients was 67.0 years (IQR 50.0–77.0 years). The ratio of men to women was 1.96. There was a unimodal age distribution, with a peak in those aged 70–79 years, which was also the peak incidence of falls (Figures 1 and 2). The TBI admissions were mostly mild in severity (82.5%; Table 1).

![Figure 1. Sex distribution of individuals with traumatic brain injury (TBI) according to age groups.](image1)

![Figure 2. Mechanism of injury according to age groups.](image2)

Patients with severe TBI were younger than those with moderate and mild TBI \((p < 0.001)\). The median age was 67 (50.0–77.0) years.

**Table 1. Baseline characteristics of patients admitted with TBI.**

| Age (years) | Median (IQR) |
|-------------|---------------|
| 67 (50.0–77.0) |

| Sex          |          |
|--------------|----------|
| Female       | 166 (33.8%) |
| Male         | 325 (66.2%) |

| Ethnicity    |          |
|--------------|----------|
| Chinese      | 363 (73.9%) |
| Indian       | 47 (9.6%)  |
| Malay        | 41 (8.4%)  |
| Other        | 40 (8.1%)  |

| Severity categories |          |
|---------------------|----------|
| Mild                | 405 (82.5%) |
| Moderate            | 39 (7.9%)  |
| Severe              | 47 (9.6%)  |

| Mechanism of TBI |          |
|------------------|----------|
| Assault          | 30 (6.1%) |
| Fall             | 377 (76.8%) |
| RTA              | 55 (11.2%) |
| Sports           | 9 (1.8%)  |
| Other            | 20 (4.1%)  |

| RLAS-R Level |          |
|--------------|----------|
| I – no response | 26 (5.3%) |
| II – generalised response | 14 (2.9%) |
| III – localised response | 20 (4.1%) |
| IV – confused and agitated | 20 (4.1%) |
| V – confused and inappropriate | 35 (7.1%) |
| VI – confused and appropriate | 64 (13%) |
| VII – automatic and appropriate | 72 (14.7%) |
| VIII–X – purposeful and appropriate | 240 (48.9%) |

| Main neuroradiological findings |          |
|---------------------------------|----------|
| SDH                             | 193 (39.3%) |
| SAH                             | 78 (15.9%) |
| Mixed                           | 70 (14.3%) |
| Concussion                      | 46 (9.4%)  |
| ICH                             | 35 (7.1%)  |
| EDH                             | 32 (6.5%)  |
| Contusion                       | 27 (5.5%)  |
| Other                           | 9 (1.8%)   |
| None                            | 1 (0.2%)   |

| Types of neurosurgical interventions |          |
|--------------------------------------|----------|
| None                                 | 384 (78.2%) |
| Burrhole surgery                     | 54 (11.0%) |
| Craniectomy                          | 34 (6.9%)  |
| Craniotomy                           | 13 (2.6%)  |
| EVD insertion                        | 2 (0.4%)   |
| ICP insertion                        | 4 (0.8%)   |

| Presence of nosocomial infection    |          |
|-------------------------------------|----------|
| Yes                                 | 83 (16.9%) |
| No                                  | 408 (83.1%) |

| Survival status |          |
|-----------------|----------|
| Alive           | 463 (94.3%) |
| Dead            | 28 (5.7%)  |

| Motor FIM       |          |
|-----------------|----------|
| Median (IQR)    | 46.0 (13.0–73.0) |

| Cognitive FIM   |          |
|-----------------|----------|
| Median (IQR)    | 30.0 (10.0–35.0) |

| Total FIM       |          |
|-----------------|----------|
| Median (IQR)    | 73.0 (28.0–103.0) |

| Acute LOS (days) |          |
|------------------|----------|
| Median (IQR)     | 7.0 (3.0–14.0) |

TBI: traumatic brain injury; IQR: interquartile range; RTA: road traffic accident; RLAS-R: Rancho Los Amigos Scale-Revised; SDH: subdural haematoma; SAH: subarachnoid haemorrhage; ICH: intracerebral haemorrhage; EDH: extradural haemorrhage; EVD: external ventricular drain; ICP: intracranial pressure; FIM: Functional Independence Measure; LOS: length of stay.
54.0 years (IQR 36.0–66.0 years) in the severe TBI group, 61.0 years (IQR 41.0–74.0 years) in the moderate TBI group and 70.0 years (IQR 54.0–78.0 years) in the mild TBI group. In the severe TBI cohort, there was a bimodal age distribution, with two peaks in those aged 30–39 and 60–69 years (Figure 3).

Falls (76.8%, n=377) were the leading mechanism of injury, followed by RTA (11.2%, n=55; Table 1). More patients <60 years old were involved in assault, RTA and sports than those aged ≥60 years old (14.7%, n=26 vs. 1.3%, n=4; 20.3%, n=36 vs. 6.1%, n=19; and 5.1%, n=9 vs. 0.0%, n=0, respectively; p<0.001). Falls affected more patients ≥60 years old (89.5%, n=281 vs. 54.2%, n=96; p<0.001).

Among patients who fell, 74.5% (n=281) were ≥60 years old (p<0.001). There were 127 mechanical falls (33.7%), 152 non-mechanical falls (40.3%) and 98 unwitnessed falls (26.0%). The median ages of patients who sustained unwitnessed, non-mechanical and mechanical falls were 70.0 years (IQR 56.0–78.0 years), 72.0 years (IQR 59.3–80.0 years) and 72.5 years (IQR 61.8–81.0 years), respectively (p=0.123).

Among the nine cases of sports-related TBI, seven involved non-contact sports (77.8%), whereas two (22.2%) involved contact sports (one boxing and one Taekwondo).

Isolated SDH constituted 39.3% (n=193) of the injuries (Table 1). In one (0.2%) individual, no signs of intracerebral injury or haemorrhage were detected on computed tomography scan. Most patients did not require neurosurgical intervention (78.2%, n=384; Table 1). Twelve (2.4%) patients required tracheostomy.

Eighty-three (16.9%) patients developed nosocomial infections, with pneumonia and urinary tract infection (UTI) being the two leading infections (90.4%). The seven cases of non-infective complications comprised one (14.3%) DVT, four (57.1%) seizures and two (28.6%) dysautonomia.

The median total AFIM was 73.0 (IQR 28.0–103.0), and the median ALOS was 7.0 days (IQR 3.0–14.0 days; Table 1). A total of 347 (70.7%) patients were directly discharged, and 116 (23.6%) patients were transferred directly to AIR (Table 2). The median ALOS of those directly discharged were shorter than those who received continuous chain of early rehabilitation (5.00 days (IQR 3.00–11.00 days) vs. 12.50 days (IQR 7.25–21.00 days); p<0.001).

Out of the 28 patients who died, 12 (42.9%) sustained a severe TBI, 10 (35.7%) sustained a mild TBI and six (21.4%) sustained a moderate TBI.

Table 2. Univariate analysis of clinical variables by discharge.

| Table 2. Univariate analysis of clinical variables by discharge. | Acute inpatient rehabilitation | p-Value |
|---------------------------------------------------------------|-------------------------------|--------|
| No, n=347 | Yes, n=116 | |
| Age (years) | Median (IQR) | 64.0 (48.0–76.0) | 72.0 (58.3–79.8) | 0.004 |
| Sex | | | | | |
| Female | 129 (37.2%) | 31 (26.7%) | 0.040 |
| Male | 218 (62.8%) | 85 (73.3%) | | |
| Severity categories | | | | | |
| Mild | 306 (88.2%) | 89 (76.7%) | 0.010 |
| Moderate | 20 (5.8%) | 13 (11.2%) | | |
| Severe | 21 (6.1%) | 14 (12.1%) | | |
| Mechanism of TBI | | | | | |
| Assault | 24 (6.9%) | 5 (4.3%) | 0.732 |
| Fall | 263 (75.8%) | 93 (80.2%) | | |
| RTA | 39 (11.2%) | 10 (8.6%) | | |
| Sports | 7 (2.0%) | 2 (1.7%) | | |
| Other | 14 (4.0%) | 6 (5.2%) | | |
| Neurosurgical intervention | | | | | |
| No | 293 (84.4%) | 72 (62.1%) | <0.001 |
| Yes | 54 (15.6%) | 44 (37.9%) | | |
| Tracheostomy | | | | | |
| No | 340 (98.0%) | 111 (95.7%) | 0.186 |
| Yes | 7 (2.0%) | 5 (4.3%) | | |
| Presence of nosocomial infection | | | | | |
| No | 314 (90.5%) | 74 (63.8%) | <0.001 |
| Yes | 33 (9.5%) | 42 (36.2%) | | |
| Presence of DVT/seizures/dysautonomia | | | | | |
| No | 343 (98.8%) | 114 (98.3%) | 0.643 |
| Yes | 4 (1.2%) | 2 (1.7%) | | |
| Total FIM on review | | | | | |
| Median (IQR) | 90.0 (48.0–109.0) | 47.0 (18.0–70.0) | <0.001 |

DVT: deep-vein thrombosis.
Clinical predictors associated with transfer to AIR

Univariate analysis indicated age, sex, severity of TBI, neurosurgical intervention, infection and total FIM on review were significantly associated with transfer to AIR (Table 2). Multivariate analysis showed infection (OR=2.95, 95% CI=1.59–5.49) and neurosurgical intervention (OR=2.18, 95% CI 1.24–3.81) increased the odds of transfer to AIR (Table 3). Higher AFIM was associated with reduced likelihood of transfer to AIR (OR=0.98, 95% CI 0.97–0.99).

Clinical characteristics of the continuous chain of early rehabilitation group

Demographics. Out of the 463 patients who survived, 116 (25.1%) patients were transferred directly to AIR, with a median age of 72.0 years (IQR 58.3–79.8 years). Most had sustained a mild injury (75.9%, n=88). Moderate and severe injuries each constituted 12.1% (n=14) of the injuries. The majority of the elderly (aged ≥60 years) sustained a mild injury (87.1%, n=74) compared to the young (aged <30 years; 16.7%, n=1). Half of those aged <30 years (50.0%, n=37) sustained a severe injury, 52.0% (n=13) of those aged 30–59 years sustained a mild injury and 87.1% (n=74) of those aged ≥60 years sustained a mild injury (p<0.001). Older age groups were moderately associated with milder injuries (r=0.473, p<0.001). Falls were the predominant cause (79.3%, n=92) followed by RTA (9.5%, n=11).

Functional recovery. Using the total DFIM to define recovery, 9.5% achieved a good recovery (FIM 109–126), 56.9% with moderate disability (FIM 72–108) and 33.6% with severe disability (FIM <72). One third (33.3%) of those aged <30 years achieved a good recovery, whereas 24% of those aged 30–59 years and 3.5% of those aged ≥60 years achieved a good recovery (p=0.002).

The median total AFIM was 58.50 (IQR 19.75–84.75); the median total DFIM was 86.00 (IQR 60.50–98.75). The total functional and motor gains after AIR were significant (p<0.001; Table 4). The median total FIM gain was 12.00 points (IQR 2.00–41.00 points). The median FIM efficiency was 0.55 (IQR 0.67–1.58) points/day.

There were no differences in total FIM gain (p=0.116), total FIM efficiency (p=0.204), motor FIM gain (p=0.327) or motor FIM efficiency (p=0.496) among the three age groups. The cognitive FIM gain and cognitive FIM efficiency were different among the three age groups (Table 5).

Table 3. Multivariate analysis predicting likelihood of acute patient rehabilitation

| Factor                      | p-Value | OR  | 95% CI       |
|-----------------------------|---------|-----|--------------|
| Age                         | 0.142   | 1.01| 1.00–1.03    |
| Male (vs. female)           | 0.050   | 1.70| 1.00–2.88    |
| Moderate TBIa               | 0.357   | 0.64| 0.25–1.66    |
| Severe TBIa                 | 0.114   | 0.47| 0.18–1.20    |
| Neurosurgical intervention  | 0.007   | 2.18| 1.24–3.81    |
| Total FIM on review         | <0.001  | 0.98| 0.97–0.99    |
| Infection                   | 0.001   | 2.95| 1.59–5.49    |

Table 4. Median (IQR) total FIM and subscale scores on admission and discharge.

|           | Admission | Discharge | FIM gain (discharge–admission) | p-Value |
|-----------|-----------|-----------|-------------------------------|---------|
| Motor FIM | 41.00 (13.00–58.00) | 61.00 (40.00–71.00) | 11.00 (2.00–25.00) | <0.001  |
| Cognitive FIM | 20.00 (5.00–30.00) | 25.00 (17.00–30.00) | 0.00 (0.00–9.00) | <0.001  |
| Total FIM | 58.50 (19.75–84.75) | 86.00 (60.50–98.75) | 12.00 (2.00–41.00) | <0.001  |

Table 5. FIM gain and FIM efficiency among the three age groups.

|                 | <30 years | 30–59 years | >60 years | p-Value |
|-----------------|-----------|-------------|-----------|---------|
| FIM gain, points (IQR) |           |             |           |         |
| Motor FIM gain   | 13.00 (0.00–48.75) | 22.00 (0.00–52.50) | 10.00 (4.00–18.00) | 0.327   |
| Cognitive FIM gain | 4.50 (0.00–21.75) | 5.00 (0.00–17.50) | 0.00 (0.00–5.00) | 0.003   |
| Total FIM gain   | 17.00 (0.75–76.00) | 30.00 (1.50–67.50) | 11.50 (2.00–21.75) | 0.116   |
| FIM efficiency, points/day (IQR) |           |             |           |         |
| Motor FIM efficiency | 0.230 (0.000–6.831) | 0.738 (0.000–2.403) | 0.440 (0.126–1.000) | 0.496   |
| Cognitive FIM efficiency | 0.053 (0.000–2.191) | 0.246 (0.000–0.846) | 0.000 (0.000–0.210) | 0.002   |
| Total FIM efficiency | 0.280 (0.004–9.023) | 1.429 (0.036–3.339) | 0.402 (0.096–1.282) | 0.204   |
the case in a recent study which reported a shift in local TBI. RTA was the leading cause in younger patients. This was also the predominant mechanism of TBI in the elderly, whereas patients, especially those aged 70–79 years, with falls being not the focus of our study.

The sex-associated risk factors for TBI in our cohort, as this is

### Table 6. Linear regression analysis on FIM gain.

| Variable               | Beta coefficient (95% CI) | p-Value |
|------------------------|---------------------------|---------|
| Age                    | −0.065 (−0.107 to −0.022) | 0.003   |
| Complications          | −1.669 (−3.185 to −0.153) | 0.031   |
| Neurosurgical intervention | −0.914 (−2.207 to 0.379) | 0.164   |
| Male                   | −0.568 (−1.998 to 0.863)  | 0.433   |
| GCS                    | −0.053 (−0.300 to 0.195)  | 0.674   |
| Motor AFIM             | −0.087 (−0.124 to −0.050) | <0.001  |
| RLOS                   | −0.039 (−0.063 to −0.016) | 0.001   |
| Cognitive AFIM         | −0.004 (−0.061 to 0.053)  | 0.894   |

Adjusted R²=0.323.

### Table 7. Linear regression analysis on FIM efficiency.

| Variable               | Beta coefficient (95% CI) | p-Value |
|------------------------|---------------------------|---------|
| Age                    | −0.252 (−0.629 to 0.076)  | 0.013   |
| Complications          | −10.502 (−20.453 to −0.552) | 0.039   |
| Neurosurgical intervention | −4.770 (−13.258 to 3.718) | 0.268   |
| Male                   | 3.687 (−5.704 to 13.077)  | 0.438   |
| GCS                    | −0.922 (−2.547 to 0.703)  | 0.263   |
| Motor AFIM             | −0.816 (−1.058 to −0.573) | <0.001  |
| RLOS                   | −0.227 (−0.381 to −0.0741) | 0.004   |
| Cognitive AFIM         | −0.179 (−0.555 to 0.197)  | 0.347   |

Adjusted R²=0.479.

30–59 and 10.00 days (IQR 7.00–21.00 days) in those aged ≥60 years (p=0.008). There was no difference in the RLOS among the age groups (p=0.891).

Linear regression analysis on FIM gain and FIM efficiency. Increased age, complications, high motor AFIM and long RLOS were associated with lower FIM gain and lower FIM efficiency (Tables 6 and 7).

### Discussion

This study provides information on the demographics of patients with TBI acutely admitted in a Singapore tertiary hospital and the functional outcomes related to a continuous chain of early rehabilitation. Most local studies focused on patients with moderate and severe TBI.21-24

Our study showed more males were admitted acutely for TBI, which was consistent with other demographic studies, as male sex has been established as a risk factor for TBI.25,26 The suggested reasons for higher TBI risk in males were related males often participating in more risk-taking behaviour, contact sports and alcohol consumption.26 We did not analyse the sex-associated risk factors for TBI in our cohort, as this is not the focus of our study. Our study showed a peak incidence of TBI in elderly patients, especially those aged 70–79 years, with falls being the predominant mechanism of TBI in the elderly, whereas RTA was the leading cause in younger patients. This was also the case in a recent study which reported a shift in local TBI demographics towards an older population, with an increased incidence of falls.27 The rates of fall-related TBI could increase due to our rapidly ageing nation, which highlights the need to identify at-risk elderly populations and strengthen fall-prevention strategies.

Our study showed that the majority of patients selected for AIR were older patients with mild TBI. Functional impairment is prevalent in mild TBI, and studies have shown that mild TBI can result in cognitive and psychosocial impairment.28,29 Older patients with mild TBI have increased risk of poor cognitive performance, which could explain their need for inpatient rehabilitation, despite the mild severity.28 Non-medical reasons for selection of mild TBI and older patients could be related to lack of caregivers (e.g. an aged spouse and/or working children), inadequate step-down facilities and limited home-care resources. We acknowledge that the demographic profile of the acute TBI admissions was skewed, with the majority of cases being mild TBI and older patients. This could have affected the profile of patients selected for AIR. Nevertheless, our study provided a snapshot of the local demographic TBI profile.

Our study showed that older age was a negative predictor of FIM gain and FIM efficiency, which is consistent with other studies.30 This was despite older patients tending to have less severe TBI than younger patients. The possible reasons could be that older patients likely had more co-morbidities, less neurological and physical reserves and a higher tendency of poly-pharmacy which could affect recovery.31-33 This could account for there being no detectable cognitive FIM gain observed in our elderly group. Other reasons for the dismal cognitive FIM gain are discussed in a later section.

There has been a frequent selection bias in clinical and research practice towards younger patients with TBI. A systematic review showed that elderly patients were being under-represented in TBI research.34 Cnossen et al. reported that age was an important determinant of referral decisions in 46% of the European neurotrauma centres, with younger patients often referred directly to specialised rehabilitation centres whereas patients aged ≥65 years were often referred directly to nursing homes or local hospitals.35 By implementing the service of early screening and review of all patients with TBI within 72 hours of acute admission, older patients have a similar opportunity as younger patients of being reviewed and accepted to AIR.

An interesting point to note from our results was that sufficient case in a recent study which reported a shift in local TBI
We recognise the term ‘mechanical fall’ has not been well defined in academic research, and what differentiates a mechanical from a non-mechanical fall is subject to interpretation. A ‘mechanical fall’ is often associated with a slip or trip leading to a fall and implies that an external mechanical force or object caused the fall.13 We are aware that external factors are rarely the sole cause of an elderly patient’s fall, and the use of ‘mechanical falls’ could inaccurately imply there is a benign cause for an elderly patient’s fall.13 As our study did not focus solely on elderly patients, we have kept the use of the term ‘mechanical fall’.

Conclusion

Our study showed most of the acute TBI admissions were older patients, with the predominant mechanism related to falls. Patients who had neurosurgical intervention or infection were shown to have increased likelihood of being transferred to AIR. There was functional improvement in patients with TBI receiving a continuous chain of early rehabilitation. Increased age, presence of complications, high motor AFIM and increased RLOS were associated with lower FIM gain and lower FIM efficiency. Further local research is warranted to confirm these findings.

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Availability of data and materials

The data sets generated and/or analysed during the current study are available from the corresponding author.

Authors’ contributions

L.S.K. was involved in the literature research, collection and analysis of data, obtaining ethical approval from Institutional Review Board and writing of the first draft. T.Q.Q. was involved in the literature research and analysis of data. S.F.C. reviewed and assisted in the statistical analysis. All authors reviewed, edited the manuscript and approved the final version of the manuscript.

Conflict of interest

L.S.K., T.Q.Q. and S.F.C. declare there are no affiliations with or financial involvement with any commercial organisation with direct financial interest in the subject or materials discussed in this manuscript.

Ethical approval

Ethical approval for this study was obtained from the Centralised Institutional Review Board (CIRB Ref 2012/333/F: Department of Rehabilitation Medicine Traumatic Brain Injury Registry and Database).

Informed consent

Waiver of informed consent was obtained from the institution’s Centralised Institutional Review Board.

Study limitations

The principal investigator and co-investigators retrospectively reviewed the medical records for the data collection. The quality of the data collection was therefore dependent on the accuracy and reliability of the records documentation and the quality of data extraction. Although we attempted to collect data on duration of post-traumatic amnesia (PTA), which is a clinically relevant prognostic indicator in TBI, much of the data were incomplete and so we were not able to report PTA duration in the results.
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