A SHORT-TERM LONGITUDINAL STUDY ON MULTI-DIMENSIONAL OUTCOMES FOLLOWING MILD TRAUMATIC BRAIN INJURY IN MULTI-ETHNIC MALAYSIA

Hamzah N[1], Muhamad N[2], Hariri F[3], Mazlan M[1], Ramli N[4], and Narayanan V[5].
[1]Department of Rehabilitation Medicine, Faculty of Medicine, University of Malaya, Malaysia
[2]Sector for Evidence-based Healthcare, National Institute of Health, Ministry of Health, Malaysia
[3]Department of Dentistry, Maxillofacial Unit, University of Malaya, Malaysia
[4]Department of Biomedical Imaging, Faculty of Medicine, University of Malaya, Malaysia
[5]Department of Surgery, Faculty of Medicine, University of Malaya, Malaysia

Correspondence:
Vairavan Narayanan,
Department of Surgery,
Faculty of Medicine,
University of Malaya
Email: nvairavan@um.edu.my

Abstract

This is a short-term longitudinal study of physical, cognitive, psychological and functional outcomes following mild traumatic brain injury (mTBI) in adults, caused by road traffic accident (RTA). Outcome measures were the Montreal Cognitive Assessment (MoCA), the Neuropsychological Assessment Battery Screening Module (S-NAB), the Patient Health Questionnaire (PHQ-9) and the Generalized Anxiety Disorder 7 (GAD-7) scale. Functional outcomes included returning to working/academia and driving, lifestyle changes, financial claims and litigation status. A total of 285 individuals were diagnosed with mTBI, involving young male motorcyclists (90%): uncomplicated mTBI, n=201; complicated mTBI, n=84. Ethnic distribution consisted of 204 Malays, 58 Indians and 23 Chinese. MoCA detected cognitive deficits (mean=23.11, SD=3.41) within 72 hours of injury. At two weeks, somatic manifestations, physical injuries, cognitive deficits and psychological symptoms were detected. At three months of injury, the language domain was persistently impaired, with a lower score on most cognitive domains in the complicated mTBI category than the uncomplicated mTBI. Psychological and somatic symptoms had improved. Almost 50% of patients had returned to a functional baseline within two weeks of injury and a further 24% within three months. A small proportion of patients made active lifestyle changes (<25%), financial injury claims (38%) and were involved in litigation (11%). In conclusion, mTBI in multi-ethnic Malaysia has multifaceted deficits and outcomes. Early management of symptoms may promote maximum recovery.

Keywords: mild traumatic brain injury, brain concussion, traffic accidents, cognitive dysfunction, longitudinal studies, Malaysia

Introduction

Mild traumatic brain injury (mTBI) is defined as an acute non-penetrating head trauma that induces transient physiological disruption of brain function. Clinical diagnostic criteria are the Glasgow Coma Scale (GCS) score of 13 to 15, loss of consciousness (LOC) of less than 30 minutes and post-traumatic amnesia (PTA) of less than 24 hours (1). Complicated mTBI includes the presence of intracranial lesion such as subarachnoid haemorrhage, and contusions or small extra-axial hematomas (2).

The most common mTBI aetiology in the low and middle-income countries (LMIC) is a road traffic accident (RTA). Incidence is highest amongst young adults in Malaysia (3, 4). RTA is also the leading cause of non-fatal TBI-related emergency department (ED) visits and hospitalisation (5). The sequelae of mTBI are widely reported (6, 7) but the long-term economic consequences are largely unknown. In one study, the estimated cost of mTBI was incremental in the first six months of injury (8). The nature of the trauma often involves multiple health providers incurring cost over an extended period of time. Economically disadvantaged patients and their families may be the hardest hit by direct medical expenses and lost wages resulting from multiple impairments.

Commonly reported symptoms encompass the somatic with headache, dizziness, and fatigue; cognitive with poor concentration and memory difficulty; psychological with irritability, depression and anxiety; and functional impairments with an inability to work, drive or socialise (7). While most patients usually recover within days or

months following trauma, a sizeable proportion continue to experience persistent disabling impairments over time (9). This cluster of symptoms is recognised as the Post-Concussion Syndrome (PCS) and appear after head trauma and persists beyond three months of injury (10). Similar symptoms may also be present in other illnesses such as depression, chronic pain, and the Post Traumatic Stress Disorder (11). The multitude of symptoms, premorbid condition, and injury duration add to the complexity of the clinical presentation of mTBI. Current literature proposes that premorbid bio psychosocial factors are strongly associated with outcome rather than the effect of injury alone (12, 13). Specifically, TBI patients from LMIC reported being less affected by the injury when compared with high-income countries, most likely from socio-cultural influences (14).

An updated guideline indicates that further evaluation and intervention are necessary if symptoms persist beyond three months (6). Recently, the Montreal Cognitive Assessment (MoCA) is applied as a screening tool for detecting cognitive deficits in mTBI at the acute stage (15). However, in-depth cognitive assessment warrants neuropsychological assessment (7). Psychological status at early injury stage is one of the predictors for recovery (16) and a return to work (RTW) status is a well-studied functional outcome in mTBI (17).

It is important to study the progress of such multifaceted deficits and outcomes in mTBI. The findings may lead to the most appropriate intervention, prevention of long-term complications and ultimately the return to full functional capacity. The purpose of this study was to assess the short-term clinical presentations and their outcomes following mTBI that was caused by RTA in a multi-racial cohort in Malaysia.

Materials and Methods

Study design

This was a prospective cohort study approved by the Medical Research Ethics Committee, UMMC (MREC ID NO: 2016928-4293).

Participants

Adult participants aged 18 to 60 years, who were diagnosed with mTBI caused by RTA, were recruited via the Emergency Department (ED), University Malaya Medical Centre (UMMC), Malaysia, from March 2017 to December 2018, a period of 21 months. Inclusion criteria were participants of Malaysian nationality with a minimum of nine years of education, who could communicate in English. Patients with previous history of head trauma, clinical evidence of substance intoxication at the time of injury, pre-existing chronic illness that might cause neurological symptom or complication, severe co-morbid neurological or psychiatric disorder or who were on long-term medication that could alter or affect their cognitive or psychological status were excluded.

Procedure

Mild TBI was diagnosed based on its classification (1). All patients underwent computed tomography (CT) brain scans and further division of mTBI category was aided by CT findings. Complicated mTBI was defined by the additional presence of intracranial contusion, haemorrhage and/or oedema or a depressed skull fracture on the day of injury (18). Once diagnosed, consent was obtained and patients were followed up at 72 hours, two weeks, and three months of injury. Data access was via UMMC digital medical record and patient review. Patients were given appointment dates and outcome measures were applied during the scheduled intervals (Figure 1).

Outcome measures

i) Demographics

Patients' demographic data, mTBI category, symptoms presentation, concomitant injuries, and medical health providers' involvement were recorded. The symptom checklist was similar to the Rivermead Post-Concussion Symptoms Questionnaire (RPCSQ) (19). However, the severity of cognitive and emotional-somatic manifestations was quantified by other specific outcome measures. Information of medical health providers' involvement was obtained through UMMC digital record.

ii) Montreal Cognitive Assessment (MoCA)

MoCA is a one-page cognitive screening test that assesses visuospatial and executive function, naming, memory, attention, language, abstraction, and orientation (20). The total MoCA score is 30. In this study, the full original English version 7.1 MoCA and the Malay language version was applied (20). A single qualified assessor performed the test and all participants completed it within 10 minutes. MoCA was performed only once, at 72 hours of injury.

iii) Neuropsychological Assessment Battery-Screening module (S-NAB)

S-NAB assesses five cognitive domains: attention, language, memory, spatial and executive function (EF). Each domain contained several subtests:

- Attention: Orientation, Digits Forward, Digits Forward Longest Span, Digits Backward, and Digits Backward Longest Span.
- Language: Auditory Comprehension, and Naming.
- Memory: Shape Learning Immediate Recognition, Shape Learning Delayed Recognition, Story Learning Immediate Recall, and Story Learning Delayed Recall.
- Spatial: Visual Discrimination, and Design Construction.
- Executive Function: Mazes, and Word Generation.

Each domain score category is compared with a neurologically healthy population matched for age, gender, and educational year. Each domain and overall cognitive performance (Total Screening Index) is scored. A score of less than 85 is categorized as impaired cognition. Further reduction of score implies worsening deficit.

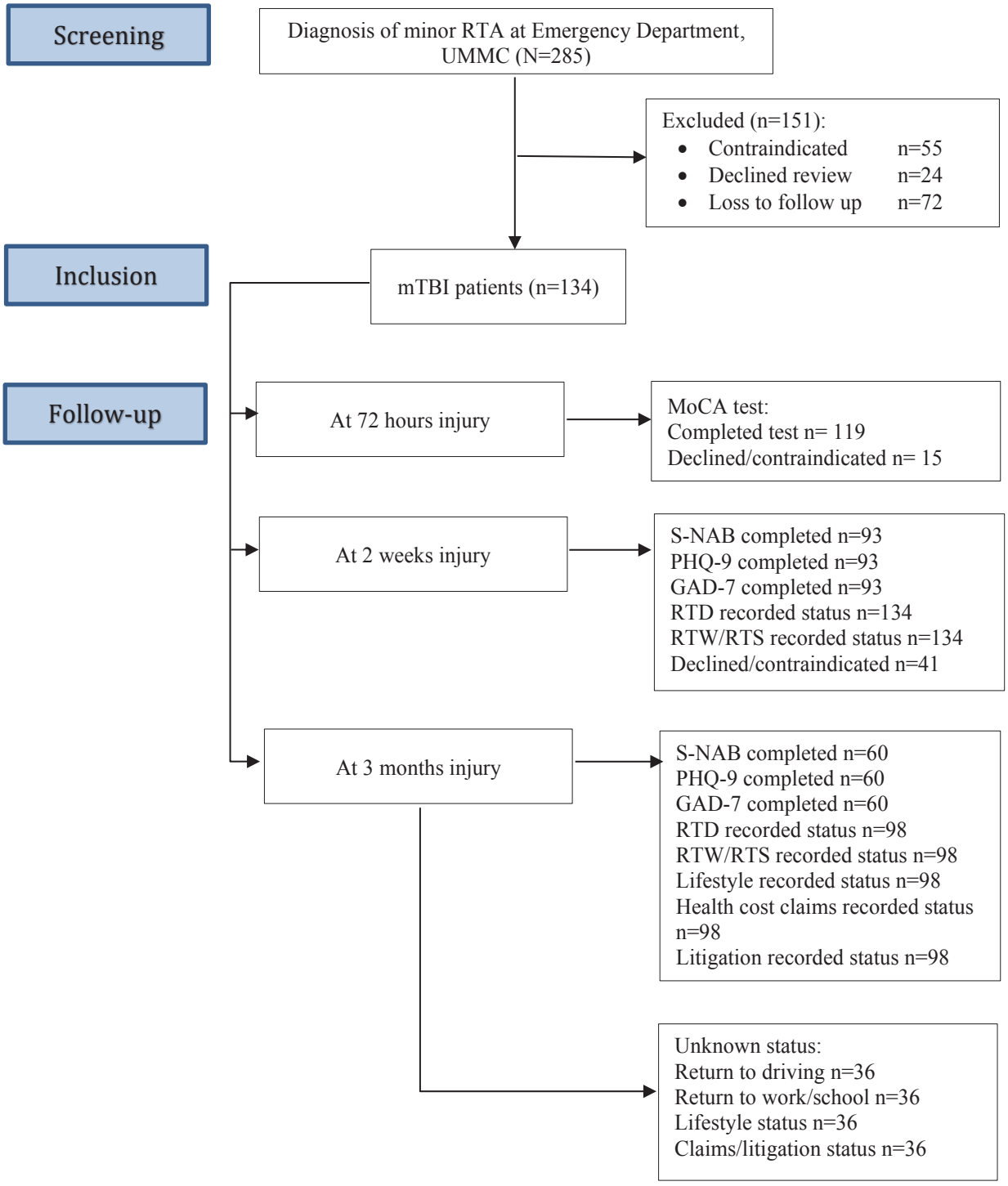

Figure 1: The flowchart of study recruitment

S-NAB was administered by a single qualified assessor (21, 22). Each participant was tested twice; at two weeks injury timepoint (Form 1) and at three months injury timepoint (Form 2). Each total test time was not more than 60 minutes. S-NAB provides two parallel assessment sets (Form 1 and Form 2) that is to be applied in alternate fashion to avoid practice effect (21). The forms consist of validated allowable differences but do not differ in construct (21).

iv) Psychological outcome measures

Anxiety was measured with the Generalized Anxiety Disorder 7 (GAD-7) scale. It is a self-reporting seven-item questionnaire divided into minimal (score 0 to 4), mild (score 5 to 9), moderate (score 10 to 14), and severe (score 15 to 21) anxiety categories (23). Depression was measured with the Patient Health Questionnaire (PHQ-9), a self-administered nine-item questionnaire that is based on the

DSM-V depression criteria. It is categorized into minimal (score <4), mild (score 5 to 9), moderate (score 10 to 14), moderately severe (score 15 to 19), and severe (score 20 to 27) categories. The alternative language format for both screening tools was available in Malay and was applied for this study (24, 25). Both screening tests were performed at two weeks and at three months of injury.

v) Functional outcome measure

Functional outcomes were descriptive analysis of RTW, return to academic studies, return to driving (RTD), lifestyle changes, litigation status, and insurance claims. All were recorded at two weeks and three months of injury.

Statistical analysis

This included descriptive analysis of demographics and all outcome measures. A t-test was performed for comparison analysis. Significant *p*-value was set at <0.05. Pearson's correlation analysis was performed between variables.

Results

Demographics

A total of 228 males and 57 female patients were diagnosed with mTBI in 21 months from March 2017 to December 2018 (Figure 1). The ethnic composition consisted of 204 Malays, 23 Chinese, and 58 Indians. The mean age was 29.08 (SD=8.54). The uncomplicated to complicated mTBI ratio was 2:1. At follow-up study phase, a total of 134 patients were reviewed, with a male: female ratio of 1:3. The mean age was 27.57 (SD=7.63) years and mean education years of 12.42 (SD=1.91) (Table 1).

Physical outcomes

Physical symptoms listed at sub-acute injury stage were consistent with RPCSQ items (Table 2). One PTSD case secondary to mTBI was diagnosed. Multiple health providers were involved in mTBI patient treatment. Cerebrovascular disease with subcortical stroke (n=5), and pontine stroke (n=1) were also diagnosed from incidental CT scan findings. Patients were asymptomatic throughout the study period and were referred to the relevant medical team for further management of their strokes.

Table 1: The characteristics of both mTBI categories

	Uncomplicated mTBI (n=201)				Complicated mTBI (n=84)			
	Mean	**Median**	**SD**	**Range**	**Mean**	**Median**	**SD**	**Range**
Age	27.87	26.00	8.02	18-54	26.50	25.00	6.27	18-46
Education (years)	12.44	11.00	2.01	9-18	12.43	11.50	1.70	11-16
Gender (%male)	-	76.3	-	-	-	72.5	-	-
Ethnicity (% Malay)	-	81.7	-	-	-	70	-	-
GAD-7	3.98	1.00	4.93	0-15	4.61	3.00	5.26	0-19
PHQ-9	4.07	2.00	5.64	0-23	5.33	3.50	5.90	0-23
Types of RTA (%)								
Motorcycle	90%				90%			
Car	5%	-	-	-	5%	-	-	-
Lorry	3%				5%			
Pedestrian	2%				-			

PHQ-9: Patient Health Questionnaire, GAD-7: Generalized Anxiety Disorder 7, SD: standard deviation

Cognitive outcomes

A total of 119 patients underwent MoCA screening within 72 hours of injury. There were 86 male and 33 female patients (Table 3). The mean total score for uncomplicated mTBI patients (n=84) was 23.8 (SD=2.82) whereas the mean score for complicated mTBI patients (n=35) was 22.06 (SD=1.78).

The two mean timepoints for S-NAB administration were 19.09 days (SD=10.37) and 87.5 days (SD=10.5) of injury. At the sub-acute stage, attention, language and EF domains were affected for uncomplicated mTBI group and except for language; similar domains were impaired for complicated mTBI group. At the chronic injury stage, attention and EF scores improved but language domain remained impaired for both groups (Table 4). In general, complicated mTBI patients scored lower for the impaired domains when compared to uncomplicated mTBI (Table 5).

Psychological outcomes

At two weeks of injury, 93 mTBI patients' GAD-7 mean total score was 4.3 (SD=5.0) and the PHQ-9 mean total score was 4.6 (SD=6.0). Sixty-five uncomplicated mTBI individuals' GAD-7 mean total score was 3.98 (SD=4.93) and the PHQ-9 mean total score was 4.07 (SD=5.64).

Table 2: Concomitant injuries at two weeks of injury and the health providers' involvement

Specialty	Patients (n)	Concomitant injury
Neurosurgery	84	Skull fracture Laceration injury *Headache
Rehabilitation medicine	84	*Headache *Fatigue *Dizziness/imbalance *Disturbed sleep *Forgetful *Poor focus/slow thinking
Ophthalmology	59	*Light sensitivity Facial bone fracture Periorbital scar management Soft tissue injury (periorbital hematoma, orbital haemorrhage)
Orthopaedic surgery	27	Fracture clavicle Fracture upper limb Fracture lower limb
Maxillofacial and dental surgery	25	Broken tooth extraction Laceration injury Maxillofacial fracture Soft tissue injury (hematoma)
Ear, Nose and Throat (ENT)	19	Nasal fracture Benign Paroxysmal Positional Vertigo (BPPV) Tinnitus Eardrum injury/ tear
Sports medicine	7	Soft tissue injury of joints (tendon/ligament/muscle tear, hematoma)
Neurology	7	Stroke management Migraine
General practice	2	Wound dressing
Psychiatry	2	Post-Traumatic Stress Disorder (PTSD) Known chronic depression
General surgery	1	Splenectomy
Dermatology	1	Flare-up of known psoriasis

*symptom listed in Rivermead Post-Concussion Symptoms Questionnaire items

Table 3: MoCA domains and total scores in all mTBI cases at 72 hours post injury

MoCA Domain (n=119)	Mean (SD)	Median	Range
Visuospatial & Executive Function	3.70 (1.46)	4	0-5
Naming	3.07 (2.90)	3	1-3
Attention	5.12 (1.08)	5	1-6
Language	1.39 (0.82)	1	0-4
Abstraction	1.50 (0.63)	2	0-3
Memory	2.97 (1.62)	3	0-5
Orientation	5.60 (0.73)	6	2-6
Total	23.11 (3.41)	24	12-29

Note: MoCA: Montreal Cognitive Assessment, SD: standard deviation

Twenty-eight complicated mTBI individuals' GAD-7 mean total score was 4.61 (SD= 5.26) and PHQ-9 mean total score was 5.33 (SD =5.90).

At three months of injury, a decline in total scores was noted for both groups. Sixty mTBI patients' GAD-7 mean total score was 2.35 (SD=2.6) and PHQ-9 mean total score was 2.5 (SD=2.57). Thirty-six uncomplicated mTBI patients' GAD-7 mean total score was 1.8 (SD=1.74) and PHQ-9 mean score was 1.9 (SD=2.25). Twenty-four complicated mTBI patients' GAD-7 mean total score was 3.0 (SD=3.34) and PHQ-9 mean score was 3.13 (SD=2.86).

Functional and lifestyle outcomes

At two weeks injury timeline, a total of 134 individuals' functional status was reported (Table 6). Almost half had returned to driving and working after two weeks injury. Those who did, had returned to previous work with temporary work adjustments to include reduction of workload or to work from home. Seven individuals (5%) had returned to work against medical advice or immediately following completed medical leave of less than two weeks duration. Three individuals (2%) who had started on new jobs prior to RTA had declined sick leave. Individuals who did not return to work within two weeks of injury were given two to six weeks medical/sick leave due

Table 4: The S- NAB Standard Domain scores for each domain for both mTBI and complicated mTBI at two weeks and three months of injury

Domain	At two weeks (n=93)			At three months (n=60)		
	Uncomplicated mTBI (n=65)	Complicated mTBI (n=28)		Uncomplicated mTBI (n=36)	Complicated mTBI (n=24)	
	Mean (SD)	Mean (SD)	p value	Mean (SD)	Mean (SD)	p value
Attention	84.80 (16.80)	73.45 (13.82)	<0.01	92.82 (15.05)	85.45 (18.44)	0.11
Language	82.97 (24.69)	86.20 (34.51)	0.45	75.09 (22.15)	80.70 (19.95)	0.16
Memory	94.49 (16.16)	95.05 (15.59)	0.28	103.60 (140.4)	100.15 (15.20)	0.85
Spatial	102.60 (13.86)	98.20 (13.95)	0.23	104.66 (13.05)	102.40 (13.30)	0.54
Executive function	82.00 (18.41)	76.20 (17.04)	0.15	84.72 (18.98)	85.85 (16.62)	0.68
Total Screening Index	83.49 (17.22)	79.45 (17.38)	0.28	87.90 (19.05)	86.05 (16.22)	0.31

Note: Standard Domain score and Total Screening Index score of <85 are in the impaired category.

Table 5: Mean S-NAB score differences within mTBI groups

Cognitive domain	Group	Mean	SD	95% CI	t	*p*
Attention	U	-8.03	9.62	-11.33 – (-4.72)	-4.94	<0.01
	C	-12.00	11.33	-17.30 – (-6.70)	-4.74	0.00
Language	U	7.89	28.28	-1.83 - 17.60	1.65	0.11
	C	5.50	26.52	-6.91 - 17.91	0.93	0.31
Memory	U	-9.11	18.98	-15.63- (-2.59)	-2.84	0.00
	C	-5.10	12.60	-11.00 - 0.80	-1.81	0.09
Visuospatial	U	-2.06	11.69	-6.07 -1.96	-1.04	0.00
	C	-4.20	13.99	-10.75 - 2.35	-1.34	0.20
Executive function	U	-2.71	36.23	-15.16 - 9.73	-0.44	0.66
	C	-9.65	9.39	-14.04 – (-5.26)	-4.60	0.00
TSI	U	19.54	47.14	3.35 - 35.74	2.45	0.02
	C	-6.60	11.06	-11.77- (-1.43)	-2.67	0.02

Note: TSI: Total Screening Index, U: uncomplicated mTBI, C: complicated mTBI, SD: standard deviation, CI: confidence interval, *p* significant value is set at <0.05

to concomitant injuries. Three individuals (2%) had opted to resign from their previous jobs following RTA. At three months of injury, two thirds of patients were able to return to previous job status. Three individuals, who had resigned at two weeks injury time point, had new employments at three months of injury.

Thirty-one individuals (23%) were unable to drive due to concomitant injuries at two weeks injury time point. Two thirds of patients were able to drive at the three months injury time point. Lifestyle changes included spiritual practice, physical exercise, 'brain' exercise, and diet change (Table 6). The majority of patients did not alter their lifestyle and daily activities following mTBI. There was also no adjustment reported for academic attendance at both injury timelines. However, respective academic institutions were notified of each student's health status.

Financial claims and litigations status

At three months of injury, less than 40% of individuals had applied for insurance schemes and social protection schemes. Only 11% of individuals were involved in litigation cases (Table 6).

Correlation analyses between demographics and outcomes

Correlation analyses were performed between ethnicity, gender, education years, and age with MoCA and S-NAB scores. There was no statistically significant correlation between gender and cognitive or psychological outcome. Weak correlations were seen between age and anxiety as well as EF domain, and between education years and MoCA (Table 7).

Discussion

The majority of mTBI caused by RTA in Malaysia involved young male individuals as similarly reported by other developing countries (4). The ethnic distribution reflected the Malaysian multi-ethnic population (7).

Table 6: Functional outcomes of mTBI population at two weeks and three months of injury

Functional outcome	At two weeks (n=134)		Unknown status at two weeks	At three months (n=98)		Unknown status at three months
	Yes (%)	No (%)	%	Yes (%)	No (%)	(%)
Return to work/school	73 (47)	35 (26)	26 (19)	95 (71)	3 (2)	36 (27)
Return to driving function	67 (50)	31 (23)	36 (27)	98 (73)	-	36 (27)
Insurance scheme	-	-	-	38 (28)	58 (43)	38 (28)
Social protection scheme	-	-	-	35 (26)	61 (46)	38 (28)
Litigation involvement	-	-	-	11 (8)	85 (63)	38 (28)
Lifestyle	-	-	-			
• **Prayer/meditation**				15 (11)	79 (59)	40 (30)
• **Physical exercise**				23 (17)	71 (53)	40 (30)
• **'Brain' exercise**				11 (8)	83 (62)	40 (30)
• **Taking supplement**				9 (7)	85 (63)	40 (30)
• **Diet change**				16 (12)	78 (58)	40 (30)

Table 7: Pearson's correlation coefficient between age and education years with cognitive and psychological outcomes

Factors	PHQ-9	GAD-7	MoCA	S-NAB at 2 weeks	S-NAB at 3 months
Age	-	0.236*	-	0.216* (Executive Function)	-
Education year	-	-	0.257**	-	-

PHQ-9: Patient Health Questionnaire-9, GAD-&: Generalised Anxiety Disorder-7, MoCA: Montreal Cognitive Assessment, S-NAB: Neuropsychological Assessment Battery-Screening Module
*correlation is significant at $p<0.05$ (two-tailed)
**correlation is significant at $p<0.01$ (two-tailed)

This study was able to detect the progress of symptoms in a single patient group: somatic symptoms of headache, dizziness, fatigue, sensory hypersensitivity; cognitive symptoms of attention, language and EF deficits; and mild psychological symptoms of anxiety and depression were detected as early as two weeks post trauma (6, 7, 9, 11). Longitudinally, several symptoms persisted for at least three months. More recently, the Diagnostic and Statistical Manual of Mental Disorders (DSM)-V, has described similar clinical presentation as mild neurocognitive disorder category in TBI (10). The diagnostic criteria must also include orthopaedic injuries and neurological symptoms, consistent with mTBI presentation (10).

In mTBI, most symptoms recovered by six months of injury (7). Interestingly, a recent study indicated that improvements in subjective cognitive symptoms after mTBI co-occur with improvements on other subjective metrics of emotional and physical symptoms, but were not related to improvements in objectively measured cognitive functioning (26). This emphasized the need for objective measurements of symptoms instead of relying on subjective symptom-reporting. This can also provide a clinical avenue for early symptoms' management and prevent progression of untreated symptoms into chronic impairments (6).

In mTBI, cognitive deficits are detectable as early as 48 hours to two weeks post-injury (7). Resolution of mixed

cognitive deficits occurs in the first month to a year (7). MoCA was able to measure mild cognitive deficits as early as 72 hours post trauma. In this study, MoCA outcome was similar between uncomplicated and complicated mTBI groups at the acute injury stage, as similarly reported by another study (15). We did not repeat MoCA to avoid the learnt effect. In-depth longitudinal cognitive assessment was further measured by S-NAB.

Although MoCA has similar test components to S-NAB, the construct, complexity and rigorousness of assessments differed (22). At two-week of injury, S-NAB demonstrated specific multiple cognitive domains and overall neuropsychological functioning deficits for both mTBI categories. At three months of injury, several domains recovered but language domain remains impaired. Indeed, the recovery pattern of cognition in mTBI differs over time and involves a specific domain. Generally, complicated mTBI performed worse than uncomplicated mTBI at two weeks injury. Longitudinally, uncomplicated mTBI outperformed complicated mTBI group in several cognitive domain scores. One study had further reported that complicated mTBI had cognitive impairment severity similar to moderate TBI category, with chronic functional deficits (27).

Anxiety and depression are commonly reported in mTBI (7, 16). The psychological symptoms to injury may also be an emotional response to temporary loss of function. Interestingly, one case of PTSD caused by the RTA was also diagnosed. However, this individual's psychological status did improve by three months of injury in tandem with improved cognition and function. A recent study had concluded that emotional distress and maladaptive coping, experienced early after mTBI injury, in combination with pre-injury mental health problems, low education, and older age are predictors for poor recovery (16).

We found weak positive correlation between age, anxiety level, and cognition. Hence, symptom screening and clinical review performed at the early stage of injury can guide clinicians to identify those with potentially poor outcome. Weak positive correlation between education year and MoCA is not surprising, as individuals with higher education may have higher cognitive reserve and hence better performance in cognitive assessments despite severity of brain injury.

The highest functional outcome priority was RTW. Indeed, RTW rate for mTBI population was high, as reported by several systematic reviews (17, 28). In this study, although RTW was achieved by many at the early stage of injury, work productivity and quality were not assessed. Early RTW was reported to occur despite medical advice or had required various temporary work adjustments. Where sick leave was provided, it was issued based on concomitant injuries and their inability to drive. RTD function was in tandem with RTW status for those with occupations directly related to driving: law enforcers, goods delivery drivers, salespersons, technicians with jobs requiring site visits. The injuries caused by RTA also affected their socio-economic status. As more patients recovered over time, more were able to return to their previous work status. Mild TBI is not a significant risk factor for long-term work disability (17). Rather, predictors of poor RTW outcome are multifactorial (17).

In Malaysia, health costs are either covered by personal funding, private saving schemes, personal insurance or social protection scheme. Insurance schemes involved either vehicle and/or personal injury insurance. Social protection schemes include Employer's Liability Scheme (ELS) for employment injury compensation, sickness benefits, Employee Provident Fund (EPF), and the Worker's Compensation Scheme under the Social Security Organization (SOCSO) (29).

This study reported a low number of financial and social protection claims. The main factor could be due to eligibility. Claims are usually made following completion of treatment or when the status of disability is established, which may take longer than three months of injury. A high proportion of patients did return to work at early stage of injury most likely to also prevent wages loss. There are also legal implications involved with financial claims. Accident reporting to the legal authority is mandatory within 24 hours or when deemed practicable (Road Transport Act 1987). It is also mandatory for vehicles to be insured in Malaysia. Accident reporting document is required to for vehicle insurance claim. A study showed that RTA reporting is directly proportionate to the level of RTA injury severity (30). Minor RTA may be under-reported for various reasons that we did not explore in this study.

Conclusion

Mild TBI is an injury that affects the physical, cognitive, psychological and functional aspects of a person. Impairments are detectable at the early stage of injury for the Malaysian mTBI population. Although full recovery is expected over time, early symptom screening is beneficial to detect severity of symptoms and the potential risk of chronic impairment. Disability may even be prevented through the initiation of early treatment.

Limitation of study

Large attrition rate occurred in this study. Patients were either uncontactable or had injuries that were deemed unsuitable for outcome measure assessment at the acute stage of trauma. Symptom screening availability was also hampered due to prioritisation of treatment, patients' psychological status and readiness for assessment. The assumption that mTBI is often underdiagnosed and undertreated is therefore multi-factorial. We did not explore in greater depth on the RTW status, litigation and financial claims in this study. A multi-centre trial and extending the duration of study may reduce the attrition rate and capture the true scale of the impact of injury.

Acknowledgement

This study is partly funded by High Impact Research Grant UM.C/625/1/HIR/MOHE/CHAN/12 and fully funded by Post Graduate Research Grant (IPPP) PPPC/C1-2016/DGJ/01.

Competing interests

All authors declare no competing interest.

Ethical clearance

Written consent was obtained from all participants of this study. This study was approved by Medical Research Ethics Committee, UMMC (MREC ID NO: 2016928-4293).

References

1. Kay T, Harrington DE, Adams R. American congress of rehabilitation medicine, head injury interdisciplinary special interest group. definition of mild traumatic brain injury. J Head Trauma Rehabil. 1993;8(3):86–7.
2. Lange RT, Brickel TA, French LM, Merritt VC, Bhagwat A, Pancholi S, *et al.* Neuropsychological outcome from uncomplicated mild, complicated mild, and moderate traumatic brain injury in us military personnel. Arch Clin Neuropsychol. 2012;27(5):480-94.
3. Rahman NHN, Baharuddin KA, Mohamad SMS. Burden of motorcycle-related injury in Malaysia. Int J Emerg Med. 2015;8(7):1-6.
4. World Health Organization. Global status report on road safety 2015. 2015. Available at: https://www.who.int/violence_injury_prevention/road_safety_status/2015/en/. Accessed 19 March 2021.
5. Taylor CA, Bell JM, Breiding MJ, Xu L. Traumatic brain injury-related emergency department visits, hospitalizations, and deaths - United States, 2007 and 2013. MMWR Surveill Summ. 2017;66(9);1–16.
6. Marshall S, Bayley M, McCullagh S, Velikonja D, Berrigan L, Ouchterlony D, *et al.* Updated clinical practice guidelines for concussion/mild traumatic brain injury and persistent symptoms. Brain Inj. 2015;29(6):688-700.
7. Carroll LJ, Cassidy JD, Cancelliere C, Côté P, Hincapié CA, Kristman VL, *et al.* Systematic review of the prognosis after mild traumatic brain injury in adults: Cognitive, psychiatric, and mortality outcomes: Results of the international collaboration on mild traumatic brain injury prognosis. Arch Phys Med Rehabil. 2014;95(3):S152-73.
8. Leibson CL, Brown AW, Hall Long K, Ransom JE, Mandrekar J, Osler TM, *et al.* Medical care costs associated with traumatic brain injury over the full spectrum of disease: A controlled population-based study. J Neurotrauma. 2012;29(11):2038-49.
9. Theadom A, Parag V, Dowell T, McPherson K, Starkey N, Barker-Collo S, *et al.* Persistent problems 1 year after mild traumatic brain injury: A longitudinal population study in New Zealand. Br J Gen Pract. 2016;66(642):16-23.
10. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 5th Ed. Arlington: American Psychiatric Association Publishing. 2013.
11. Ontario Neurotrauma Foundation. Guidelines for concussion/mild traumatic brain injury and persistent symptoms - For adults (18+ years of age). 3rd Ed. Toronto, Canada: Ontario Neurotrauma Foundation. 2018.
12. Losoi H, Silverberg ND, Wäljas M, Turunen S, Rosti-Otajärvi E, Helminen M, *et al.* Recovery from mild traumatic brain injury in previously healthy adults. J Neurotrauma. 2016;15;33(8):766-76.
13. Wäljas M, Iverson GL, Lange RT, Hakulinen U, Dastidar P, Huhtala H, *et al.* A prospective biopsychosocial study of the persistent post-concussion symptoms following mild traumatic brain injury. J Neurotrauma. 2015;15;32(8):534-47.
14. De Silva MJ, Roberts I, Perel P, Edwards P, Kenward MG, Fernandes J, *et al.* Patient outcome after traumatic brain injury in high-, middle- and low-income countries: Analysis of data on 8927 patients in 46 countries. Int J Epidemiol. 2009;38(2):452-8.
15. De Guise E, Alturki AY, LeBlanc J, Champoux MC, Couturier C, Lamoureux J, *et al.* The montreal cognitive assessment in persons with traumatic brain injury. Appl Neuropsychol. 2014;21(2):128-35.
16. Van der Naalt J, Timmerman ME, de Koning ME, Van der Horn HJ, Scheenen ME, Jacobs B, *et al.* Early predictors of outcome after mild traumatic brain injury (UPFRONT): an observational cohort study. Lancet Neurol. 2017;16(7):532-40.
17. Cancelliere C, Kristman VL, Cassidy JD, Hincapié CA, Côté P, Boyle E, *et al.* Systematic review of return to work after mild traumatic brain injury: Results of the international collaboration on mild traumatic brain injury prognosis. Arch Phys Med Rehabil. 2014;95(3):201-9.
18. Williams DH, Levin HS, Eisenberg HM. Mild head injury classification. Neurosurgery. 1990;27(3):422-8.
19. Ganti L, Daneshvar Y, Ayala S, Bodhit AN, Peters KR. The value of neurocognitive testing for acute outcomes after mild traumatic brain injury. Mil Med Res. 2016;3(23):1-7.
20. Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, *et al*. The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment. J Am Geriatr Soc. 2005;53(4):695-9.
21. White T, Stern RA. Neuropsychological assessment battery NAB® psychometric and technical manual evidence based on theory and test content. 2nd Ed. Florida, USA: Hebben & Milberg. 2002.
22. Hamzah N, Mohamad NA, Thiruselvam I, Hariri F, Veeramuthu V, Mazlan M, *et al.* Validity and reliability of the Neuropsychological Assessment Battery – Screening module (S-NAB) in a subset of Malaysian population with mild traumatic brain injury (mTBI). Appl Neuropsychol Adult. 2019;21(8):1-11.

23. Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: The GAD-7. Arch Intern Med. 2006;166(10):1092-7.
24. Azah MNN, Shah MEM, Juwita S, Bahri IS, Rushidi WMWM, Jamil YM. Validation of the Malay version brief Patient Health Questionnaire (PHQ-9) among adult attending family medicine clinics. Int Med J. 2005;12(4):259-63.
25. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: Validity of a brief depression severity measure. J Gen Intern Med. 2001;16(9):606-13.
26. Stenberg J, Karr JE, Terry DP, Håberg AK, Vik A, Skandsen T, *et al.* Change in self-reported cognitive symptoms after mild traumatic brain injury is associated with changes in emotional and somatic symptoms and not changes in cognitive performance. Neuropsychology. 2020;34(5):560-8.
27. Kashluba S, Hanks RA, Casey JE, Millis SR. Neuropsychologic and functional outcome after complicated mild traumatic brain injury. Arch Phys Med Rehabil. 2008;89(5):904-11.
28. Bloom B, Thomas S, Ahrensberg JM, Weaver R, Fowler A, Bestwick J, *et al.* A systematic review and meta-analysis of return to work after mild Traumatic brain injury. Brain Inj. 2018;32(13-14):1623-36.
29. Zin RHM, Lee HA, Rahman SA. Social protection in Malaysia. Int Soc Sci J. 2001:119-69.
30. Kamaluddin NA, Abd Rahman MF, Várhelyi A. Matching of police and hospital road crash casualty records – a data-linkage study in Malaysia. Int J Inj Contr Saf Promot. 2019;26(1):52-9.