

# The Rate of Return to Driving after Traumatic Brain Injury in Malaysia and the Changes in Driving Behaviour

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## ABSTRACT

**Objectives:** To examine the rate of return to driving among patients with traumatic brain injury (TBI) in Malaysia and its associated factors; and to identify the changes in their driving behavioural pattern.

**Study design:** A cross sectional study.

**Setting:** A tertiary hospital in an urban setting in Malaysia.

**Subjects:** TBI patients of more than six months duration with valid driving licenses, driving cars and/or riding motorcycles prior to the TBI and attended the outpatient clinic follow-up from December 2019 to June 2020

**Methods:** Personal and medical data were collected via face-to-face interview using a structured questionnaire and from the electronic medical record, respectively.

**Results:** A total of 52 patients were interviewed with the average age of 39.4 (12.7) years. The commonest cause of TBI was motor vehicle accident (MVA) (86.5%) with almost half (46.1%) of the patients returned to driving post-TBI within the range of 6 months to 17 years. Majority of the post-TBI drivers (70.8%) underwent a formal driver retraining program. This study found that both the cognitive status ( $p < 0.05$ ,  $d = 0.1$ ) and the functional status ( $p < 0.05$ ,  $d = 0.1$ ) were significantly associated with return to driving. Changes in driving behavioural pattern were reported in 70.8% of the drivers.

**Conclusions:** The rate of return to driving among patients with TBI is low. Hence there is a need to address the underlying barriers to return to drive in a comprehensive driving rehabilitation program post-TBI.

**Keywords:** driving, rehabilitation, traumatic brain injury, vehicle

ASEAN J Rehabil Med. 2021; 31(3): 105-110.

## Introduction

Ability to drive is regarded as an instrument for a person's independence and mobility. By gaining the skills and capacities to drive, a person can participate in recreational, educational, and economical activities, return to employment, and indirectly achieve a better quality of life.<sup>1</sup> This statement is

true across the population spectrum from the abled-body and the less-abled. Since majority of the traumatic brain injury (TBI) survivors are from the younger adult age group, ability to drive is crucial for a better community integration.<sup>2,3</sup> The ability to return to drive becomes increasingly important in countries like Malaysia, where the public transportation is not optimal for people with disabilities. According to a recent qualitative study, majority of the respondents from an urban area in Malaysia were not satisfied with the reliability, safety and accessibility of the public bus services available.<sup>4</sup>

Due to congested city roads and underdeveloped network of public transportation, the two preferred modes of transportation are compact cars and motorcycles. Between the two, motorcycle has been the most preferable, convenient, and affordable mode of transport. It is not surprising that motorcycle riders account for majority of the motor vehicle accident (MVA) victims and fifty eight percent of transport fatalities in Malaysia are from motorcycle accidents.<sup>5</sup> Therefore, to suit the local context, we defined return to driving as the ability to driving cars and/or riding motorcycles.

The ability to drive in persons with TBI is affected in many ways.<sup>6</sup> There are common complications post-TBI which are absolute contraindications to return to driving such as seizure and visual impairments, e.g., homonymous hemianopia and diplopia.<sup>7,8</sup> Relatively, persons with TBI can have some degree of cognitive deficit, balance impairments, paretic limbs and poor coordination<sup>9</sup> which hinder them from return to driving fully. Psychological and environmental factors such as fear, lack of confidence, post-traumatic stress disorder and denial by concerned family members to allow return to driving are also important reasons affecting their ability to return to drive.<sup>2</sup>

A previous study conducted in New Jersey, United States reported that as high as 85% of persons with TBI were able to return to driving.<sup>3</sup> There is no information available for the post-TBI drivers in Malaysia or its neighbouring countries. Therefore, the purpose of this study was to investigate the rate of return to driving in persons with TBI in Malaysia. We

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Received: 16<sup>th</sup> January 2021

Revised: 9<sup>th</sup> March 2021

Accepted: 19<sup>th</sup> July 2021

also wish to explore the associated factors of returning to drive and identify the driving behavior changes in TBI survivors.

## Methods

The present study was approved by University Malaya Medical Center (UMMC) Medical Research Ethics Committee, identification number: 2019429-7366.

### Participants

TBI patients who attended the outpatient specialist Brain Injury Rehabilitation clinic follow-up in UMMC, Malaysia from December 2019 to June 2020 were screened.

The inclusion criteria were age over 18 years old, history of TBI of more than 6 months, having a valid license and driving cars and/or riding motorcycles prior to TBI. The exclusion criteria were having concomitant physical disabilities other than TBI and acute ongoing medical illness.

### Materials

The data was collected using a self-constructed questionnaire that was specifically designed based on the objectives of this study. The questionnaire has four sections: the first three sections consist of patients' demographic data, disease-specific characteristics and patients' driving exposure respectively, while the fourth part explores return to driving experience.

### Study protocol

A pilot study using the questionnaire was conducted on 10 patients and necessary modifications were made after getting feedbacks from the patients. The principal investigator administered the questionnaire personally after consent was obtained via face-to-face interview with the patients. The average length of time for each interview was 10 minutes.

Each patient was informed of the objectives, confidentiality, and voluntary participation of this study. The patients' medical data was cross-checked with their Electronic Medical Record (EMR).

### Statistical analysis

The descriptive analysis for categorical variables were expressed in frequencies and percentages. Post-TBI drivers and ex-drivers were assessed with regards to their demographic, biographical and medical characteristics using chi-square tests and independent sample t-tests. All statistically significant independent variables ( $p < 0.05$ ) were evaluated to tease out collinearity. We then calculated the predictive power (effect Size) using Cohen's  $d$  formula using the univariate analysis.

## Results

Seventy-one patients from the clinic were identified from Dec 2019 to June 2020. Nineteen patients were excluded

because of these reasons: 16 did not fulfil the inclusion criteria, two have other concomitant physical disabilities other than TBI such as spinal cord injuries and traumatic amputations and one have an acute medical illness.

In total, 52 patients were recruited in this study. We were unable to proceed with the recruitment as planned earlier, due to the sudden national lockdown. The study centre was designated as one of the major covid-19 hospitals in the country and the time constraint to complete the study.

The mean age at the time of interview was 39.4 (12.7) years old. The youngest and oldest patients was 19 years old and 70 years old, respectively. The mean age at TBI was 35.9 (13.7) years old. The mean duration since TBI was 3.5 years (4.5) years. The male to female ratio was approximately 6:1 (45 males, 7 females). Slightly more than half (57.7%) of the patients were Malay and married (55.8%). The demographic and disease-specific characteristics are shown in Table 1.

### Return to driving

All patients were driving/riding prior to TBI in which 21 of them (40.4%) rode motorcycles only, 14 (26.9%) drove cars

**Table 1.** Baseline demographic characteristics

Variables	N (%)
Sex	
Male	45 (86.5)
Female	7 (13.5)
Race	
Malay	30 (57.7)
Indian	13 (25.0)
Chinese	9 (17.3)
Marital status	
Married	29 (55.8)
Single	16 (30.8)
Separated	7 (13.5)
Educational level	
Tertiary	23 (44.2)
Secondary	19 (32.7)
Primary	10 (23.1)
Employment status	
Employed	39 (75.0)
Unemployed	9 (17.3)
Student	4 (7.7)
Etiology of injury	
MVA	45 (86.5)
Fall	4 (7.7)
Others	3 (5.8)
Severity of injury	
Severe	42 (80.8)
Moderate	6 (11.5)
Mild	4 (7.7)
Complications post-TBI	
Cognitive	41 (78.8)
Physical	35 (67.3)
Behaviour	22 (42.3)
Speech, language, hearing and taste	22 (42.3)
Vision	17 (32.7)
Others	6 (11.5)

MVA, motor vehicle accident; TBI, traumatic brain injury

**Table 2.** Factors associated with return to driving post-traumatic brain injury.

Variables	Drivers (n = 24)	Ex-drivers (n = 28)	p-value
Sex			
Male	20	25	0.690
Female	4	3	
Educational level			
Tertiary	13	10	0.162
Secondary	9	10	
Primary	2	8	
Employment status			
Employed	20	18	0.358
Unemployed	3	7	
Student	1	3	
Severity of injury			
Severe	18	24	0.519
Moderate	3	3	
Mild	3	1	
Length of coma			
Weeks	11	21	0.211
Days	5	3	
Hours	4	2	
NA	4	2	
Cognitive status (MoCA score)			
Normal (26-30)	18	11	0.002*
Mild impairment (18-25)	6	7	
Moderate/severe impairment (< 18)	0	10	
Functional Status (MBI score)			
Normal independency level (100)	19	11	0.002*
Minimal independency level (91-99)	4	5	
Moderate/severe independency level (< 91)	1	12	
Current age			
Mean (SD)	36.5 (9.9)	41.8 (14.5)	0.131
Age at TBI			
Mean (SD)	33.0 (10.2)	38.4 (15.9)	0.166
Age at license achievement			
Mean (SD)	20 (2.6)	22 (4.3)	0.056
Years of driving pre-TBI			
Mean (SD)	15 (10.4)	18.8 (14.5)	0.297
Years post-TBI			
Mean (SD)	3.5 (3.3)	3.6 (3.9)	0.970

NA, not applicable; MoCA, Montreal Cognitive Assessment; MBI, Modified Barthel Index; SD, standard deviation; MVA, motor vehicle accident; TBI, traumatic brain injury

\* $p < 0.05$  is considered significant

only and another 17 (32.7%), both. The mean duration of driving pre-TBI was 17 (12.8) years and the mean age at driving license achievement was 21.1 (3.8) years old. Out of the 52 patients, 24 (46.2%) returned to driving after the TBI. However, one patient stopped driving recently due to newly diagnosed amnesia. From those who return to driving, 17 (70.8%) attended the formal driving retraining program prior to on-road driving.

From 24 patients with TBI who returned to driving (classified as drivers); 18 had severe TBI, three had moderate TBI and another 3 had mild TBI. From the 17 patients with normal cognitive status and returned to driving; 13 had severe TBI, four had moderate TBI and one had mild TBI. From the 19

patients who were functionally independent and returned to driving, 14 had severe TBI, three had moderate TBI and another two had mild TBI.

For those who were unable to return to driving (classified as ex-drivers); 24 had severe TBI, three had moderate TBI and one had mild TBI.

#### Factors influencing return to driving

Patients with TBI who achieved normal cognitive status (Montreal Cognitive Assessment (MoCA) score  $> 25$ ) were significantly ( $p < 0.05$ ) associated with return to driving as compared to those who had mild to severe cognitive status. Patients with TBI who were functionally independent (Modified

Barthel activity daily living Index (MBI) score of 100) were also significantly ( $p < 0.05$ ) associated with return to driving as compared to those who needed some degree of assistance in their activities of daily living. The Cohen's effect size values for both MoCA score and MBI score suggested a small practical significance ( $d = 0.08$  and  $d = 0.07$  respectively). Other demographic descriptions were not significantly associated with return to driving as shown in Table 2.

### Changes in driving behaviour

Majority of the patients (94.2%) were driving daily prior to TBI. Table 3 shows the driving behavioural changes for those who resumed driving. Only three drivers reported accidents post-TBI and these accidents were minor. The frequency of driving post-TBI were reduced with less than one third (26.9%) of drivers maintaining daily driving. More than two-thirds of the drivers reported changes in their driving behaviour post-TBI. Among those who reported changes in their driving behavioural pattern, almost one third (29.2%) of drivers reported avoidance from driving into cities, rush hour and unknown places whilst another quarter (25%) reported driving only during daytime post-TBI. Six out of the twenty-four drivers (25%) were unable to return to ride motorcycles and preferred to only drive cars, although they were able to ride motorcycles and drive cars before TBI.

### Barriers to return to driving

Patients who did not return to driving ( $n = 28$ ) were asked to state the most important barrier that prevented them from doing so. The most reported barrier by ex-drivers (67.9%) were permanent residual impairments post-TBI (including limb paresis, visual deficits, cognitive impairments, limb and seizure) followed with fear and phobia (17.9%) as well as denied by concerned family members (10.7%) as shown in Table 4. All the patients without permanent residual impairments have normal or only mild impairments in cognitive status and similarly, have normal or only minimal dependency function.

### Discussion

This is the first study in Malaysia examining the rate of return to driving after TBI, the factors associated with return to driving and exploring the driving behavioural changes. From the literature, the rate of return to driving post-TBI ranged between 36 to 85 percent.<sup>2,3,10-12</sup> In this study, we found a lower rate with 46% of persons with TBI returned to drive. This is similar to findings observed in Michigan, United States<sup>2</sup> and in Warwick, United Kingdom<sup>11</sup> which reported a rate of 39 and 36 percent, respectively. These studies have similar patients to ours with majority of them suffered moderate to severe TBI (74.5% and 89.2%). We expected that persons with more severe form of TBI to have less likelihood of returning to driving, especially if we examined them early after TBI. Thus, it is not surprising that the proportion of people with

**Table 3.** Driving behaviour changes post-traumatic brain injury

Driving behaviour	n (%)
No changes	7 (29.2)
Avoidance of cities, rush hour, unknown places	7 (29.2)
Only drives during daytime	6 (25.0)
Stops riding a motorcycle and only drives a car	6 (25.0)
Driving more slowly	5 (20.8)
Others	1 (4.2)

**Table 4.** Barriers to return to driving

Reasons not returning to drive	Permanent residual impairments (n = 19)	Other barriers (n = 9)
Current age, mean (SD)	42.4 (13.9)	40.6 (16.4)
Age at TBI, mean (SD)	38.1 (15.7)	39.0 (12.3)
Severity of TBI, n (%)		
Severe	16 (57.1)	8 (28.6)
Moderate	2 (7.1)	1 (3.6)
Mild	1 (3.6)	0 (0)
Cognitive status (MoCA score), n (%)		
Normal (26-30)	4 (14.3)	7 (25.0)

TBI, traumatic brain injury; MoCA, Montreal Cognitive Assessment

severe TBI who did not return to drive was higher compared to those who returned to drive (85% vs 75%).

TBI severity alone was not shown to consistently predict return to driving, especially in the longer follow-up period. Persons with mild TBI are known to return to driving earlier,<sup>13</sup> however Novack et al.<sup>14</sup> found that the severity of TBI was not a major factor to return to driving after 5 years. This study has shown that the ability to return to driving were significantly associated with normal cognitive status and being functionally independent in personal activity of daily living (ADL) despite the initial TBI severity. These findings are in line with other reports.<sup>11,12,15</sup> We measured the persons with TBI cognitive and functional statuses during outpatient clinic follow-up, with the mean duration of 3.5 years post-TBI. In the study by Cullen et al.,<sup>12</sup> persons with TBI cognitive and functional statuses were measured at rehabilitation admission around two months post-TBI and reported them to be significant predictors for return to driving. Other studies which examined the sociodemographic profiles and driving experiences pre- and post-TBI have found conflicting results with return to driving after TBI.<sup>10,14,16,17</sup>

Among the twenty-four drivers who returned to driving, seventeen (70.8%) underwent the driving assessment and passed. In Malaysia, the national guideline on the requirement of return to non-commercial driving after a disability (including TBI) includes assessment by a physician according to the Medical Examination Standards for Disable Driver's Licensing by the Ministry of Health Malaysia.<sup>7</sup> On-road driving assessment is not a formal procedure for driving assessment after TBI in Malaysia. To ensure the safety of the persons with TBI when they resume driving, we also advised for a full evaluation by the clinicians which include a set of cogni-

tive assessments related to driving and a driving simulator testing. In this study, we did not examine the association between the driving simulator test results and the driving behaviour pattern because of the small sample size.

Most of our drivers (70.8%) reported changes in driving behaviour pattern post-TBI. These patterns were also observed in another study.<sup>18</sup> These changes are expected in persons with TBI who suffered some degrees of medical, cognition, physical and emotional complications as driving is a complex activity. It is interesting to highlight that six out of twenty-four drivers (25%) reported that they were unable to return to riding motorcycles and preferred to driving cars instead, although they were able to ride motorcycles before TBI.

We believe the reason for this preference is because riding a motorcycle is distinctly different than driving a car. A motorcycle rider needs to have a better balance and posture to control the vehicle as well as the passenger (pillion rider). Motorcycle rider is also viewed to have more exposure to driving hazards in contrast to a car driver. We believe that having a riding simulator in the country would have increased the confidence to return to riding among persons with TBI. However, there is no literature examining a riding simulator's role in return to riding motorcycles.

More than half (54%) of the persons with TBI in our study did not return to driving. Permanent residual impairments were identified as the most common barrier in this study. Permanent residual impairments reported include both absolute contraindications (post-traumatic seizure, visual deficit and cognitive impairment) and relative contraindications (limb paresis and imbalance). About thirty percent of the barriers reported were not directly related to impairments after TBI. These were reported in patients who have normal or mild impairment in cognition and function.

They were prevented from driving by concerned family members and significant others. Coleman et al.<sup>17</sup> have reported that the perceptions of driving fitness by significant others are only modestly related to actual driving ability. An education program and family reassurance may improve the likelihood of driving in certified drivers. Fear of driving was another barrier to driving. A formal screening to rule out post-traumatic stress disorder or excessive fear and anxiety is warranted in patients who did not return to drive despite no significant residual impairments. The screening can be conducted as part of the driving assessment by the clinicians mentioned earlier. These patients can be referred for the necessary treatment and intervention.

This study has its own limitation, it is a cross sectional study with a small sample size due to the sudden lockdown in the country. There is also a selection bias as this study was conducted in a single urban tertiary centre, which manages the more severe TBI population and has a driving rehabilitation unit, thus the result of this study needs to be carefully generalised. This study population may be more representative of the moderate to severe TBI population since we have

a very small number of mild TBI survivors.

Prospective research can also compare the components of driving assessment results of both drivers and ex-drivers. Validated questionnaires can be utilized to explore driving behaviours, for example the Driving Behaviour Questionnaire,<sup>19-21</sup> and the barriers to driving for example, the Barriers to Driving Questionnaire.<sup>2</sup>

## Conclusions

This study has shown that the rate of return to driving is relatively low among Malaysians with TBI. However, the rate is not different from previous study in other countries, and this could be largely attributed to the severity of the brain injury among the survivors and the severe complications that they have. Driving requires a seamless interaction of wide range cognitive skills. In addition, factors such as driving license regulation after brain injury, personal and familial risk perception, and professional and economic necessities need to be addressed to facilitate return to driving post TBI. A comprehensive driving rehabilitation program which addresses all the factors may improve the rate of returning to drive after TBI in each center.

## Disclosure

The authors declare no conflict of interest of any kind.

## Acknowledgements

This work was supported partly by the UM Postgraduate Research Fund (PO058-2015A).

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