

# Epidemiologic Characteristics of Patients Presenting with Head Injury due to Road Traffic Accident and Factors Associated with Outcome: Experience of a Tertiary Care Center in Northern Kerala

Mandaka Parambil Rajeev<sup>1</sup> Vattaparambil Shinihas<sup>1</sup> Pankaj Singh Chauhan<sup>1</sup>

<sup>1</sup>Government Medical College, Kozhikode, Kerala, India

**Address for correspondence** Pankaj Singh Chauhan, MBBS, MS, MCh (Neurosurgery), Government Medical College Kozhikode, Kozhikode 673008, Kerala, India (e-mail: pankajschauhan2011@gmail.com).

Indian J Neurosurg 2019;8:39–46

## Abstract

**Background** In India, most factors related to road traffic accident (RTA) causation and outcome go improperly documented, and database regarding RTA-related traumatic brain injury (TBI) seems inadequate. Two-wheeler drivers form the largest segment of people affected by RTA. The socioeconomic and neurologic burden, imposed by TBI due to RTAs (largely preventable), is overwhelmingly significant, especially for a developing country like India.

**Materials and Methods** Descriptive study involving patients, presenting to the casualty of Government Medical College, Kozhikode, Kerala, was performed, and various demographic features were analyzed. Usage of helmet and history of alcohol intake were also noted. Patients were evaluated according to their presenting Glasgow coma scale (GCS), investigated and either operated or managed conservatively, and their outcome was assessed with Glasgow outcome score (GOS) at 3 months.

**Results** Bike drivers formed the single largest proportion of RTA victims (53.7%). Proportion of helmet users was 17.9%, whereas 21.9% were found with history of alcohol intake. There was a consistent trend toward a favorable outcome in patients with no alcohol intake (17.08% deaths compared with 34.07% patients with alcohol intake) and with helmet usage (14.55% compared with 22.18% in patients without helmet). However, the absolute contribution of these factors cannot be inferred.

**Conclusion** Various factors related to RTA need evaluation for pooling and compilation of data at regional and national levels. Mandatory helmet laws and strict implementation and provision of subsidized helmets (standard, full coverage) will go a long way in reducing the burden on limited health resources.

## Keywords

- ▶ road traffic accident
- ▶ helmet
- ▶ alcohol

## Introduction

It is often understated that accidents (particularly road traffic accident [RTA]) introduce the most sudden, unexpected, and disabling change in the victim's life, introducing lack of productivity and requiring treatment, supportive care, and, often, dependence for daily needs. The burden (economic

or otherwise) of neurologic disability is substantial to a developing country like India.

There has been a gradual increase in the number of personal vehicles (bikes, cars, etc.) on the road. Increasing number of motorcycles has been shown to be associated with increasing number of motorcycle crashes. Various factors associated with increased risk of accidents have been enumerated.

## received

July 29, 2018

## accepted after revision

October 3, 2018

## published online

April 22, 2019

**DOI** <https://doi.org/10.1055/s-0039-1678468>

10.1055/s-0039-1678468

**ISSN** 2277-954X.

©2019 Neurological Surgeons'

Society of India

## License terms



There seems to be a lack of national or regional database to calculate the incidence, magnitude, or burden of neurologic disability due to RTA. This study was undertaken to address the same concern.

## Method

This descriptive study was undertaken in Government Medical College and Hospital, Kozhikode, Kerala (from January 1, 2017 to June 30, 2017). All patients coming to casualty were enrolled as per the following inclusion criteria: two-wheeler driving patients presenting after RTA and aged  $\geq 13$  years (pediatric patients not enrolled), patients with radiologic abnormality on computed tomography (CT) of the brain, and patients with no radiologic abnormality on initial CT but with Glasgow coma scale (GCS)  $< 15$ . Patients who were lost in follow-up or elected to go to other centers were excluded from the study ( $n = 83$ ). Patients were classified into mild/moderate/severe traumatic brain injury (TBI) and managed accordingly. Data were collected according to structured proforma for history taking (including history of alcohol intake, helmet use, mode of injury), clinical examination (including GCS at admission, pupillary reaction/symmetry, hemodynamic status, level of consciousness), and radiologic evaluation (nature of intracranial injury and its evolution on CT, X-ray to rule out associated fractures, etc.). Patients were managed either conservatively or with active intervention, on a case-to-case basis. Glasgow outcome score (GOS) was assessed at 3 months for all patients. Four groups of bike driver patients were compared: SH—sober person with helmet, SF—sober person with free head (non-helmeted), AH—person with alcohol intake with helmet, AF—person with alcohol with free head (non-helmeted).

Pediatric patients were not enrolled in the study, as pediatric emergencies are handled separately in our institution.

## Results

In this study, patients presenting to our casualty (from January 1, 2017 to June 30, 2017) were included and followed up for a period of 3 months further. The distribution of patients according to various parameters studied is given along with.

In this study; of all RTA victims (1,145 patients) coming to our casualty in a period of 6 months, the minimum and maximum ages recorded were 13 and 91 years, respectively. The subset of victims most commonly affected in RTA (i.e., two-wheeler drivers, 615 in number, 53.7%) was found to have age range from 13 to 72 years in our study (median age 30).

Maximum number of patients were found to be in their second and third decades, likely to be at their most productive years (24.9% and 24.1%, respectively). Other than 615 two-wheeler drivers (all males) with RTAs, the number of female two-wheeler drivers was 13. None was found to have consumed alcohol. At time of crash, six wore helmets.

For uniformity, further analysis pertains only to male bike drivers. Helmet use was reported in 17.9% people, and the rest 82.1% were non-helmeted at time of crash. Alcohol was a factor in 21.9% of RTAs (all males).

## Analysis

Patients coming to our casualty were found to have head injury from varied causes, in order being RTA (83.1%), fall (15.2%), assault (1%), and others (0.7%, e.g., coconut fall on head, collapse of roof on head). In a similar study, Agarwal et al<sup>1</sup> in 2012 reported that RTA causes head injury in 56.3% cases.

The GCS serves as a useful tool for rapid assessment, stratification, prognostication, serial assessment, interobserver communication, and easy reproducibility. GCS at presentation has been found to be a significant predictor of outcome. In this study, the distribution of patients with GCS score 3–8, 9–12, and 13–15 was found to be 19, 20, and 61%, respectively.

Patients were managed either with operation (25.4%), conservatively (reason being either relatively mild injury (59%), or diffuse nature of injury/very severe injury with poor prognosis (15.6%)). All patients were analyzed for outcome at 3 months by GOS. The overall mortality associated with GCS ranges of 3–8, 9–12, and 13–15 was found to be 65.8, 33.3, and 2.7%, respectively, in this study.

The distribution of injury types in this study included subarachnoid hemorrhage (SAH) (31.1%), subdural hematoma (SDH) (22.4%), epidural hematoma (EDH) (15.4%), contusion (14.0%), diffuse axonal injury (DAI) (3.9%), depressed fracture (1.3%), and mixed injury (11.9%) (►Table 1). Overall mortality for all categories of bike driver patients included AF (34.4%), AH (28.6%), SF (18%), and SH (13.6%).

In a study by Tripathi et al<sup>2</sup> in 2014, the proportion of two-wheeler vehicle driver patients using helmet was found to be 16.5%. The percentage of two-wheeler drivers using helmet was found to be 17.9%, among patients presenting to our casualty. This may differ from the proportion of helmet usage in the general population. Reasons for not wearing helmet included (1) lack of helmet, (2) too short a trip to wear helmet, (3) inconvenience (heat, humidity), (4) lack of cosmesis, as per females, and (5) lack of helmet storing facility in the two-wheeler. Other and similar reasons for decreased helmet usage were elucidated by Wadhvaniya et al in 2015.<sup>3</sup>

In this study, 21.9% of patients were found to have consumed alcohol at the time of crash. In the study by Tripathi et al in 2014, 22.5% patients were found to have used alcohol.

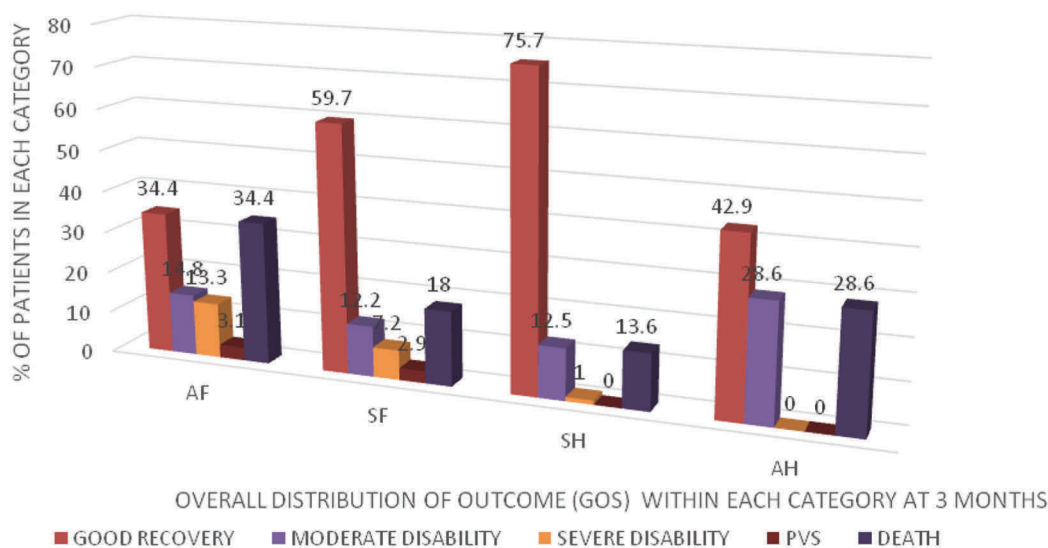
A consistent relationship was noted between GCS at presentation and GOS at 3 months. Analysis was done to compare the GOS of each category of patients (i.e., patients with helmet, without helmet, patients with and without alcohol intake; see ►Fig. 1, ►Table 2). Overall, consistent trends toward favorable outcome were noted in patients without alcohol (34.07% deaths in patients with alcohol intake compared with 17.08% deaths in nonusers; see ►Fig. 2).

The comparison of helmet users and nonusers revealed favorable trends in helmet users in mild to moderate

**Table 1** Distribution showing types of injuries in all categories of biker patients

			Imaging							Total
			Contusion	DAI	Depressed fracture	EDH	Mixed injury	SAH	SDH	
Type of victim	AF	Count % within type of victim	20 15.6%	6 4.7%	1 0.8%	21 16.4%	21 16.4%	25 19.5%	34 26.6%	128 100%
	AH	Count % within type of victim	0 0%	2 28.6%	0 0%	0 0%	1 14.3%	2 28.6%	2 28.6%	7 100%
	SF	Count % within type of victim	58 15.4%	11 2.9%	6 1.6%	74 19.6%	35 9.3%	95 25.2%	98 26%	377 100%
	SH	Count % within type of victim	8 7.8%	5 4.9%	1 1%	0 0%	16 15.5%	69 67%	4 3.9%	103 100%
Total	Count % within type of victim	86 14%	24 3.9%	8 1.3%	95 15.4%	73 11.9%	191 31.1%	138 22.4%	615 100%	

Abbreviations: AF, alcoholic patient, free head (non-helmeted); AH, alcoholic patient, helmet; DAI, diffuse axonal injury; EDH, epidural hematoma; GCS, Glasgow coma scale; GOS, Glasgow outcome score; SF, sober patient, free head (non-helmeted); SAH, subarachnoid hemorrhage; SDH, subdural hematoma; SH, sober patient, helmet.



**Fig. 1** Distribution of outcome (GOS) at 3 months. AF, alcoholic patient, free head (non-helmeted); AH, alcoholic patient, helmet; GCS, Glasgow coma scale; GOS, Glasgow outcome score; PVS, persistent vegetative state; SF, sober patient, free head (non-helmeted); SH, sober patient, helmet.

injury (GCS 13–15 and 9–12; see ►Fig. 3). The proportion of overall deaths in patients with and without helmets was 14.55% and 22.18%, respectively. In patients with severe head injury (GCS 3–8), the use of helmets fails to show a significant advantage in terms of outcome over nonusers—possibly because (1) the driver with helmet may be deemed to undergo much more severe impact to sustain the same degree of head injury as a nonuser and (2) with severe impact, a driver is likely to sustain other/multiple body injuries that contribute to mortality. It has been described previously, by Shibata et al<sup>4</sup> that there is no added benefit from a helmet at crash speed > 50 km/h.

More studies may be called for to elaborate further on other parameters of significance in two-wheeler accidents, for example helmet make and type, blood alcohol levels at the time of crash, crash speed, factors related to vehicle type, and

road conditions. This study may serve to highlight the need for regional and national databases in the form of structured format for RTA-related data and subsequent guidelines.

Glasgow outcome score for the groups with GCS 3–8, 9–12, and 13–15 is described according to the table along with.

## Discussion

This study is an attempt to highlight various factors associated with RTAs: occurrence, management, and outcome. Factors associated with RTA may be categorized as related to either man, method, material, or machine. For example:

- Man—more than or equal to two pillion riders on two-wheeler, use of alcohol, lack of helmet, lack of skill/license, unawareness of traffic rules

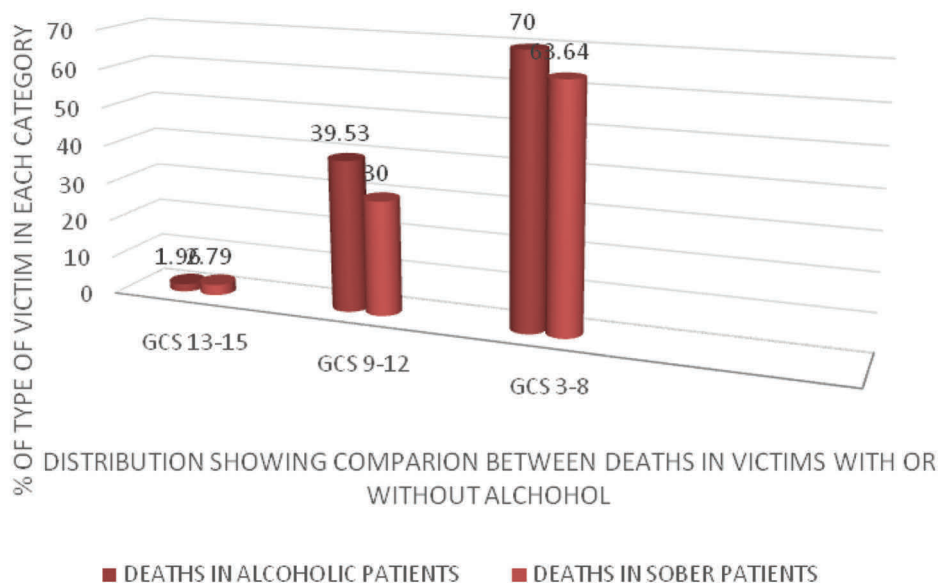
**Table 2** Distribution of all categories of biker patients according to GCS at presentation and GOS at 3 months

GCS at presentation				GOS at 3 months					
				Death	Good recovery	Moderate disability	PVS	Severe disability	Total
13–15	Type of victim	AF	Count % within type of victim	1 2%	35 71.4%	8 16.3%	0 0%	5 10.2%	49 100%
		AH	Count % within type of victim	0 0%	1 33.3%	2 66.7%	0 0%	0 0%	3 100%
		SF	Count % within type of victim	8 3.2%	203 82.2%	23 9.3%	3 1.2%	10 4%	247 100%
		SH	Count % within type of victim	1 1.3%	68 89.5%	6 7.9%	0 0%	1 1.3%	76 100%
	Total	Count % within type of victim	10 2.7%	307 81.9%	39 10.4%	0 0%	16 4.3%	375 100%	
3–8	Type of victim	AF	Count % within type of victim	26 70.3%	2 5.4%	1 2.7%	0 0%	5 13.5%	37 100%
		AH	Count % within type of victim	2 66.7%	1 33.3%	0 0%	0 0%	0 0%	3 100%
		SF	Count % within type of victim	36 61%	6 10.2%	8 13.6%	2 3.4%	7 11.9%	59 100%
		SH	Count % within type of victim	13 72.2%	3 16.7%	2 11.1%	0 0%	0 0%	18 100%
	Total	Count % within type of victim	77 65.8%	12 10.3%	11 9.4%	5 4.3%	12 10.3%	117 100%	
9–12	Type of victim	AF	Count % within type of victim	17 40.5%	7 16.7%	10 23.8%	1 2.4%	7 16.7%	42 100%
		AH	Count % within type of victim	0 0%	1 100%	0 0%	0 0%	0 0%	1 100%
		SF	Count % within type of victim	24 33.8%	16 22.5%	15 21.1%	6 8.5%	10 14.1%	71 100%
		SH	Count % within type of victim	0 0%	7 77.8%	2 22.2%	0 0%	0 0%	9 100%
	Total	Count % within type of victim	41 33.3%	31 25.2%	27 22%	7 5.7%	17 13.8%	123 100%	
Total	Type of victim	AF	Count % within type of victim	44 34.4%	44 34.4%	19 14.8%	4 3.1%	17 13.3%	128 100%
		AH	Count % within type of victim	2 28.6%	3 42.9%	2 28.6%	0 0%	0 0%	7 100%
		SF	Count % within type of victim	68 18%	225 59.7%	46 12.2%	11 2.9%	27 7.2%	377 100%
		SH	Count % within type of victim	14 13.6%	78 75.7%	10 9.7%	0 0%	1 1%	103 100%
	Total	Count % within type of victim	128 20.8%	350 56.9%	77 12.5%	15 2.4%	45 7.3%	615 100%	

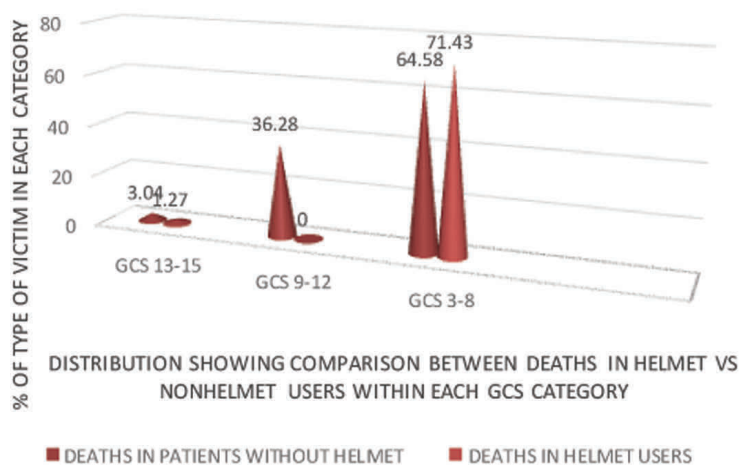
Abbreviations: AF, alcoholic patient, free head (non-helmeted); AH, alcoholic patient, helmet; GCS, Glasgow coma scale; GOS, Glasgow outcome score; PVS, persistent vegetative state; SF, sober patient, free head (non-helmeted); SH, sober patient, helmet.

- Method—rash driving/overspeed, ignoring traffic rules, using mobile while on road, wrong side driving, lack of heavy penalty
- Material—sloppy and rough road conditions, slippery surface, heavy rains, no checkpoints, roads with heavy traffic loads, encroachments on road sides, presence of animals on road, sudden turns, bad road conditions
- Machine—racing bikes, unfit vehicles on the road.

Perusing through published open access literature, an approximate estimate of the costs involved in TBI management can be made, as outlined by various studies. The estimated economic cost of TBI in the United States in 2010, including direct and indirect medical costs, was approximately \$76.5 billion (Centers for Disease Control and Prevention [CDC] report); however, these data exist mostly for developed countries. Similar data for developing



**Fig. 2** Deaths between alcohol users and nonusers. AF, alcoholic patient, free head (non-helmeted); AH, alcoholic patient, helmet; GCS, Glasgow coma scale; GOS, Glasgow outcome score; SF, sober patient, free head (non-helmeted); SH, sober patient, helmet.



**Fig. 3** Deaths between helmet users and nonusers. AF, alcoholic patient, free head (non-helmeted); AH, alcoholic patient, helmet; GCS, Glasgow coma scale; GOS, Glasgow outcome score; SF, sober patient, free head (non-helmeted); SH, sober patient, helmet.

countries, like India, are seemingly lacking. More studies such as this may contribute to forming a pool of data that can then be compiled to form a national policy.

According to an article by Das et al,<sup>5</sup> only a fraction of the 1.4 million annual RTAs in India is recorded.

As per indianheadinjuryfoundation.org, in India 1 out of 6 trauma victims dies, whereas 1 out of 200 dies in the United States. According to the Ministry of Road Transport and Highways, Government of India (2007), 140,000 road accidents happened in 2007 with 40,612 people killed and 150,000 people injured. Corresponding figures for 2016 stand at 150,785 killed and another 494,624 injured in 480,652 road crashes (analysis of data by Ministry of Road Transport and Highways, 2016).<sup>6</sup> India leads the world in fatalities due to road accidents.<sup>5</sup> In India, the studies are performed either

from traffic police records or from the hospitals.<sup>7-9</sup> Coming mostly from metro cities and based on medicolegal records, the incidences of RTA may not be absolutely correct.<sup>7,10-12</sup> In India, the incidence of head injury is steadily increasing with urbanization and increasing number of vehicles on the road.<sup>7,9</sup>

Among the victims of road traffic accidents, 70% have head injury; among road accident deaths, head injury accounts for 70% of all deaths.<sup>8</sup> Most deaths occur during first 72 hours. Recently, it has been noted that the number of fatal accidents has increased in India.

In India, 60% of all TBIs are caused by RTA. In this study, this contribution was 83%. Alcohol involvement was 21.9% compared with the reported national average of 15 to 20%. A 38 to 43% mortality rate is estimated in severe TBI. Most of



those injured in RTA are considered vulnerable road users—pedestrians, motorcyclists, four-wheel vehicle operators, and pedal cyclists.

Much has been discussed about the impact of helmet use and controversies surrounding mandatory helmet laws. It is self-evident that helmets provide some protection, even if the degree of that protection remains disputed. An excellent review comparing multiple studies may be had from the *Journal of Trauma—Injury, Infection, and Critical Care*, 2010.<sup>13</sup> During a motorcycle crash, the rider is thrown off and the head hits an object. The forward motion of the head is stopped, but the brain continues to move until it strikes the inside of the skull. It then rebounds hitting the opposite side of the skull. The damage that results varies from minor head injuries to instantaneous death (depending on the amount of energy transferred in the crash).<sup>14</sup>

In India, different types of helmets available (e.g., full-face helmets, open face helmets, and half-head helmets) are used by people. Half-head helmets do not offer any protection in the event of a crash.<sup>15</sup> Full-face helmets perform better in preventing head injuries over other helmet types, which may result from coverage of the entire head and the presence of a chin bar.<sup>16</sup>

As per the World Health organization (WHO), “wearing a helmet is the single most effective way of reducing head injuries and fatalities resulting from motorcycle crashes.” Previous studies by the National Institute of Mental Health and Neurosciences (NIMHANS) in Bengaluru, India, have shown that in the event of nonusage of helmet, there exists a more than two times increased risk of death and severe brain injury; neurologic disability is increased by one and half times. The extent of hospitalization and health care costs are significantly higher for care of an injured person due to a crash.<sup>15,17</sup> Helmet usage effectively reduces head injuries among motorcyclists; even so, a considerable proportion of motorcycle riders who wear helmets still sustain head injuries in crashes.<sup>18,19</sup> It is not uncommon to observe a helmet getting detached at the time of a motorcycle crash.<sup>19,20</sup> Head injuries seem to occur more frequently and are more severe for riders who wear a non-standard helmet compared with those who wear a standard helmet.<sup>21</sup> The use of borrowed and poorly fitting helmets is widely reported in many developing countries. More than one-third of riders use a helmet improperly, such as wearing it on the back of the head and leaving the chin strap loose.<sup>21,22</sup> In this study, the proportion of helmet users was reported to be 17.9%. Interestingly, the most common scenario was of a bystander claiming (in ~ 32% cases) an improperly strapped nonstandard helmet, flying off at the time of impact. We are prompted to suggest that data regarding helmet usage be collected mandatorily, by first attending ambulance drivers/police wherever applicable. Helmets require replacement if it has been involved in a bike crash, dropped on a hard surface, or with visible signs of damage to the shell, foam, or straps, or every 3 to 5 years.

Alcohol makes a significant contribution to the morbidity and mortality of trauma patients, regardless of the type of injury suffered.<sup>23–26</sup> Serum alcohol levels correlate closely with the extent of injury.<sup>27–29</sup> In 2006,

alcohol intoxication was involved in 32% of fatal motor vehicle crashes in the United States.<sup>30</sup> Data from the United States reveal that 35 to 81% of the injured patients in TBI were found to be alcohol-intoxicated<sup>31,32</sup> and 42% of the TBI patients were heavy drinkers before injury.<sup>32</sup> Several laboratory studies conducted to investigate relationship between alcohol and TBI, using a variety of animal models, support the concept that alcohol worsens TBI. Tien et al in 2006 were the first to report significant differences in mortality in TBI patients depending on blood alcohol levels,<sup>33</sup> wherein compared with the no alcohol reference group, the high alcohol group demonstrated worse survival rates. In 2008, O’Phelan et al reported similar findings in a more diverse population, including patients with substance abuse as well as alcohol intoxication.<sup>34</sup> Regarding the influence of pre-TBI alcohol on neuropsychological testing, most researchers studying individuals with alcohol abuse and/or dependence prior to TBI have found inferior performance on neuropsychological/cognitive testing in alcohol-intoxicated patients with TBI.<sup>35–38</sup> Alcohol consumption may have its effect in TBI by multiple mechanisms. From being a causative agent for increased risk-taking tendency to a decrease in responsible behavior (e.g., affecting carrying or wearing helmets), it impairs reaction time at the moment leading to the crash; impairs neurologic evaluation; and may be associated with chronic malnutrition, immunosuppression, or coagulopathy.

Analysis from this study shows that most accidents take place between 7 p.m. and 1 a.m. In a similar study from Nigeria by Onwuchekwa and Echem, maximum frequency of accident and emergency department visits was found during night duty shift.<sup>39</sup> This may be contributed to by poor visibility, fatigue after a hectic day at work, indulging in overspeeding due to relatively less traffic, and hurrying to reach destination. Kerala police website identifies certain areas in Kozhikode (e.g., Nadakkav, Erhanipalam, Thodayad, etc.) as having a particularly higher frequency of RTAs. Total number of RTAs in Kerala in 2016 was projected as 39,420, leading to 44,108 victims. The median average length of stay in intensive care unit (ICU) and hospital in our setting were 12 and 32 days, respectively.

Regarding the economic and social cost of road traffic crashes in India, an excellent review of the methodology and limitations in assessing the cost analysis of RTA by Dinesh Mohan<sup>40</sup> suggests the cost of road crash injuries as close to 3% of gross domestic product (GDP). For 2016, this approximates to 55,000 crores or 8.2 billion. Similar figures are echoed by the Ministry of Road Transport and Highways, Government of India. These estimates indicate the magnitude of priority that the preventive aspect of RTA-related TBI entails.

## Limitations of the Study

The patient sample may not be reflective of the total RTA-affected population segment. The reasons for this may be preference of patients to reach the hospital nearest to the site of accident. This study has very fewer number of car driving victims possibly reflecting an upper class socioeconomic

preference for private hospitals. At present, there seems to be no mandatory interdepartmental collaboration and between various hospitals to share data or regular audit regarding RTA incidence and demographic factors. The available printed format of history taking does not reflect various risk factors responsible for RTA. A detailed comparison between severity of injury and various helmet types could not be done in this study, due to relative paucity of adequate numbers of patients in each category.

## Conclusion

This study highlights the needs for centralized database for national and regional RTA-related neurologic disability assessment. In this study, almost 10 to 15% cases were lost to follow-up. This was partly due to patients not reporting to going to other centers but also due to lack of computerization, different OPD serial number at subsequent visits, and lack of provisions or regulations requiring pooling of data in chronological manner.

Mandatory collaboration between various registries (about the incidence and factors involved in the accident) should be instituted to arrive at correct regional figures.

Multipronged approach to the effective implementation of helmet laws is required, more so because it targets the most vulnerable segment affected in RTAs; hence, it is likely to cause the most significant improvement in TBI outcome, as a single measure. Regular educational outreach programs, distribution of standard ISO helmets with chin strap at subsidized prices at institutions or organizations, and strict punitive action against offenders may go a long way in achieving reduction in TBI-related morbidity and loss of productivity. The assessed cost of transport, treatment, ventilator, and ICU and hospital stay may well prove less than the cost of preventive helmet distribution.

## References

- Agrawal A, Galwankar S, Kapil V, et al. Epidemiology and clinical characteristics of traumatic brain injuries in a rural setting in Maharashtra, India. 2007–2009. *Int J Crit Illn Inj Sci* 2012;2(3):167–171
- Tripathi M, Tewari MK, Mukherjee K, Mathuriya SN. Profile of patients with head injury among vehicular accidents: an experience from a tertiary care centre of India. *Neurol India* 2014;62(6):610–617
- Wadhvaniya S, Gupta S, Tetali S, Josyula LK, Gururaj G, Hyder AA. The validity of self-reported helmet use among motorcyclists in India. *WHO South-East Asia J Public Health* 2015;4(1):38–44
- Shibata A, Fukuda K. Risk factors of fatality in motor vehicle traffic accidents. *Accid Anal Prev* 1994;26(3):391–397
- Das A, Botticello AL, Wylie GR, Radhakrishnan K. Neurologic disability: a hidden epidemic for India. *Neurology* 2012;79(21):2146–2147
- Road accidents in India—2016. New Delhi, Delhi: Ministry of Road Transport & Highways Transport Research Wing; 2016
- Report of Road Safety Cell: Ministry of Transport. Govt. of India; 1993
- Ramamurthi B. Road accidents, epidemiology and prevention. *Neurol India* 1995;43(Suppl):9–15
- Mahapatra AK. Current management of head injury. *Neuroscience Today* 1997;1:197–204
- Fife D, Faich G, Hollinshead W, Boynton W. Incidence and outcome of hospital-treated head injury in Rhode Island. *Am J Public Health* 1986;76(7):773–778
- Editorial: Head injuries: a neglected field in India. *National Medical Journal* 1991;4:44–53
- Sambasivan M. Epidemiology of neurotraumatic. *Neurol India* 1993;3(Suppl):41
- MacLeod J, DiGiacomo JC, Tinkoff G. An evidence-based review: helmet efficacy to reduce head injury and mortality: EAST practice management guidelines. *J Trauma* 2010;69(5):1101–1111
- Yadukul S, Devadass PK, Gururaj G. Role of helmet in preventing head injury among two wheeler occupants in fatal road traffic injuries. *Indian Journal of Forensic Medicine & Toxicology* 2016 Jan–Jun;10(1):6–10
- Gururaj G. Head Injuries & Helmets: Helmet Legislation and Enforcement in Karnataka and India. Bangalore, India: National Institute of Mental Health & Neuro Sciences; 2005
- Yu W-Y, Chen C-Y, Chiu W-T, Lin M-R. Effectiveness of different types of motorcycle helmets and effects of their improper use on head injuries. *Int J Epidemiol* 2011;40(3):794–803
- Helmets: A Road Safety Manual for Decision Makers and Practitioners. Geneva, Switzerland: World Health Organization; 2006
- Sarkar S, Peek C, Kraus JF. Fatal injuries in motorcycle riders according to helmet use. *J Trauma* 1995;38(2):242–245
- Richter M, Otte D, Lehmann U, et al. Head injury mechanisms in helmet-protected motorcyclists: prospective multicenter study. *J Trauma* 2001;51(5):949–958
- Richards PG. Detachment of crash helmets during motorcycle accidents. *Br Med J (Clin Res Ed)* 1984;288(6419):758
- Peek-Asa C, McArthur DL, Kraus JF. The prevalence of non-standard helmet use and head injuries among motorcycle riders. *Accid Anal Prev* 1999;31(3):229–233
- Conrad P, Bradshaw YS, Lamsudin R, Kasniyah N, Costello C. Helmets, injuries and cultural definitions: motorcycle injury in urban Indonesia. *Accid Anal Prev* 1996;28(2):193–200
- NHTSA. The Economic Impact of Motor Vehicle Crashes. Washington, DC: Dept of Transportation (US), National Highway Traffic Safety Administration (NHTSA); 2000. <http://www.dot.gov/safety.html>
- The Economic Impact of Motor Vehicle Crashes 2000. Washington, DC: Dept of Transportation, National Highway Traffic Safety Administration; 2000. <http://www-nrd.nhtsa.dot.gov/Pubs/>
- U.S. Dept. of Transportation, National Highway Traffic Safety Division. Traffic Safety Facts 1996: Alcohol. Washington, DC: National Center for Statistics & Analysis, Research & Development; 1997
- Stewart RM, Myers JG, Dent DL, et al. Seven hundred fifty-three consecutive deaths in a level I trauma center: the argument for injury prevention. *J Trauma* 2003;54(1):66–70, discussion 70–71
- Fabbri A, Marchesini G, Morselli-Labate AM, et al. Positive blood alcohol concentration and road accidents. A prospective study in an Italian emergency department. *Emerg Med J* 2002;19(3):210–214
- Pories SE, Gamelli RL, Vacek P, Goodwin G, Shinozaki T, Harris F. Intoxication and injury. *J Trauma* 1992;32(1):60–64
- Waller PF, Stewart JR, Hansen AR, Stutts JC, Popkin CL, Rodgman EA. The potentiating effects of alcohol on driver injury. *JAMA* 1986;256(11):1461–1466

- 30 National Highway Traffic Safety Administration. Traffic Safety Facts. 2006
- 31 Corrigan JD. Substance abuse as a mediating factor in outcome from traumatic brain injury. *Arch Phys Med Rehabil* 1995;76(4):302-309
- 32 Kolakowsky-Hayner SA, Gourley EV III, Kreutzer JS, Marwitz JH, Cifu DX, Mckinley WO. Pre-injury substance abuse among persons with brain injury and persons with spinal cord injury. *Brain Inj* 1999;13(8):571-581
- 33 Tien HC, Tremblay LN, Rizoli SB, et al. Association between alcohol and mortality in patients with severe traumatic head injury. *Arch Surg* 2006;141(12):1185-1191, discussion 1192
- 34 O'Phelan K, McArthur DL, Chang CW, Green D, Hovda DA. The impact of substance abuse on mortality in patients with severe traumatic brain injury. *J Trauma* 2008;65(3):674-677
- 35 Jorge RE, Starkstein SE, Arndt S, Moser D, Crespo-Facorro B, Robinson RG. Alcohol misuse and mood disorders following traumatic brain injury. *Arch Gen Psychiatry* 2005;62(7):742-749
- 36 Bombardier CH, Thurber CA. Blood alcohol level and early cognitive status after traumatic brain injury. *Brain Inj* 1998;12(9):725-734
- 37 Kelly MP, Johnson CT, Knoller N, Drubach DA, Winslow MM. Substance abuse, traumatic brain injury and neuropsychological outcome. *Brain Inj* 1997;11(6):391-402
- 38 Tate PS, Freed DM, Bombardier CH, Harter SL, Brinkman S. Traumatic brain injury: influence of blood alcohol level on post-acute cognitive function. *Brain Inj* 1999;13(10):767-784
- 39 Onwuchekwa RC, Echem RC. An epidemiologic study of traumatic head injuries in the emergency department of a tertiary health institution. *J Med Trop* 2018;20:24-29
- 40 Proceedings First Safe Community Conference on Cost of Injury. Viborg, Denmark, October 2002:33-38