

Research Article

PROTECTIVE EFFECT OF HELMET USE ON INJURY SEVERITY AMONG TWO-WHEELER ROAD TRAFFIC ACCIDENT VICTIMS: A PROSPECTIVE OBSERVATIONAL STUDY FROM WESTERN RAJASTHAN

¹Dr. Narendra kumar Vaishnawa, ²Dr. Shubham Chauhan, ³Dr. Ravindra Charan

¹Assistant Professor, Department of Forensic Medicine & Toxicology, Dr. S. N. Medical College, Jodhpur, Rajasthan

²Senior Resident, Department of Forensic Medicine & Toxicology, Dr. S. N. Medical College, Jodhpur, Rajasthan

³Senior Resident, Department of Forensic Medicine & Toxicology, Government. Medical College, Pali, Rajasthan

Corresponding author

Dr. Narendra kumar Vaishnawa

i4uherealways@gmail.com

ABSTRACT

Background: Two-wheeler road traffic accidents (RTAs) are a major cause of morbidity and mortality worldwide, with head injuries representing the leading cause of death and long-term disability. Helmet use is a proven preventive measure that substantially reduces the severity of head injuries; however, compliance remains suboptimal, particularly in low- and middle-income countries.

Aim: To evaluate the protective effect of helmet use on injury severity among victims of two-wheeler road traffic accidents.

Materials and Methods: A prospective observational study was conducted in the Department of Forensic Medicine and Toxicology, Dr. S.N. Medical College, Jodhpur, Rajasthan, from August 2024 to January 2025. A total of 100 consecutive medico-legal cases involving two-wheeler RTAs were included. Demographic characteristics, helmet use, mechanism of

collision, injury patterns, fracture distribution, cerebral injuries, and survival outcomes were recorded. Statistical analysis was performed using IBM SPSS version 26.0, and categorical variables were compared using the Chi-square test or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Results: Of the 100 participants, 83% were males and 77% were riders. Helmet use was observed in 70% of victims and was significantly higher among riders than pillion passengers (83.1% vs. 26.1%; $p < 0.001$). Frontal-impact collisions were the most common mechanism of injury (57%). Abrasions predominated across all anatomical regions, while lower-limb fractures, particularly tibia and fibula fractures, were the most frequent skeletal injuries. Head and neck injuries were relatively uncommon, with skull fractures and cerebral injuries observed in only 6% and 5% of participants, respectively. No

significant association was found between gender and helmet use ($p=0.163$). All participants survived during the study period.

Conclusion: Helmet use was associated with a lower burden of severe head and neck injuries among two-wheeler accident victims, supporting its vital role in reducing injury severity. Strengthening enforcement of universal helmet legislation, particularly among pillion passengers, alongside sustained road safety education, is essential to reduce preventable injuries and improve trauma outcomes.

Keywords: Helmet; Road traffic accident; Two-wheeler; Injury severity; Head injury; Motorcycle safety

INTRODUCTION

Road traffic injuries (RTIs) remain a major global public health challenge, accounting for approximately 1.19 million deaths and more than 50 million non-fatal injuries annually. Two-wheeler riders constitute one of the most vulnerable road user groups, particularly in low- and middle-income countries where motorcycles represent a predominant mode of transportation. In India, motorcycles and scooters account for the largest proportion of registered vehicles, and two-wheeler crashes contribute substantially to trauma-related morbidity, mortality, and disability. Despite advances in trauma care, prevention through effective safety measures remains the most practical strategy for reducing injury burden [1, 2]. Head injury is the leading cause of death and long-term neurological disability among two-wheeler crash victims. The absence of adequate cranial protection during a

collision exposes riders to severe traumatic brain injury (TBI), skull fractures, intracranial hemorrhage, and polytrauma. Numerous epidemiological studies have demonstrated that the severity of injuries sustained during road traffic accidents is influenced by factors such as helmet use, collision mechanism, impact velocity, alcohol consumption, and timely access to emergency medical care [3, 4]. Helmet use is one of the most effective and cost-efficient interventions for preventing serious head injuries among motorcyclists. Properly certified helmets absorb and dissipate impact energy, thereby reducing direct transmission of force to the skull and brain. Evidence indicates that helmet use reduces the risk of death by approximately 42% and the risk of head injury by nearly 69%. Furthermore, helmeted riders are more likely to sustain less severe injuries, require fewer neurosurgical interventions, and experience better functional outcomes than non-helmeted riders [5, 6]. India has implemented mandatory helmet legislation under the Motor Vehicles Act; however, compliance remains inconsistent due to inadequate enforcement, poor public awareness, socioeconomic factors, and improper helmet use. Consequently, severe head injuries continue to impose a significant burden on healthcare systems and contribute to avoidable mortality, prolonged hospitalization, and economic loss. Recent hospital-based studies from India have consistently reported lower injury severity scores and better survival among helmet users compared with non-users, emphasizing

the continued importance of helmet compliance [7-9].

Although several studies have evaluated helmet effectiveness, regional variations in traffic patterns, riding behavior, and trauma epidemiology necessitate institution-specific evidence. Assessing the relationship between helmet use and injury severity among two-wheeler accident victims can provide valuable information for clinicians, trauma policymakers, and road safety authorities. Such evidence may strengthen public health interventions, improve enforcement of helmet laws, and support targeted educational campaigns aimed at reducing preventable injuries and fatalities.

MATERIALS AND METHODS

Study Design and Setting: This prospective observational study was conducted in the Department of Forensic Medicine and Toxicology, Dr. S.N. Medical College, Jodhpur, Rajasthan, from August 2024 to January 2025. The study evaluated the association between helmet use and injury severity among victims of two-wheeler road traffic accidents.

Study Population: The study included 100 consecutive medico-legal cases of two-wheeler road traffic accidents presenting during the study period.

Inclusion Criteria

- Riders or pillion passengers involved in two-wheeler RTAs
- Patients of all age groups and both sexes
- Cases presenting during the study period with complete medico-legal and clinical records

Exclusion Criteria

- Accidents not involving two-wheelers

- Non-road traffic injuries
- Cases with incomplete records or insufficient clinical information
- Injuries primarily attributable to pre-existing medical conditions

Data Collection: Data were collected using a predesigned proforma from medico-legal records, First Information Reports (FIRs), inquest reports, hospital case sheets, accident registers, clinical examination findings, and radiological investigations. Information regarding demographic characteristics, rider status, helmet use, mechanism of collision, injury pattern, fracture distribution, cerebral injuries, and survival outcome was recorded systematically.

Outcome Measures: The primary outcome was the association between helmet use and injury severity, particularly head and neck injuries. Secondary outcomes included helmet compliance among riders and pillion passengers, fracture pattern, cerebral injuries, mechanism of collision, anatomical distribution of injuries, and survival outcome.

Statistical Analysis: Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 26.0. Categorical variables were expressed as frequencies and percentages and compared using the Chi-square test or Fisher's exact test, as appropriate. A p-value <0.05 was considered statistically significant.

Ethical Considerations: The study was approved by the Institutional Ethics Committee of Dr. S.N. Medical College, Jodhpur, and conducted in accordance with the Declaration of Helsinki and ICMR

National Ethical Guidelines. Written informed consent was obtained from all participants or their legally authorized representatives, and confidentiality of patient information was strictly maintained.

RESULTS

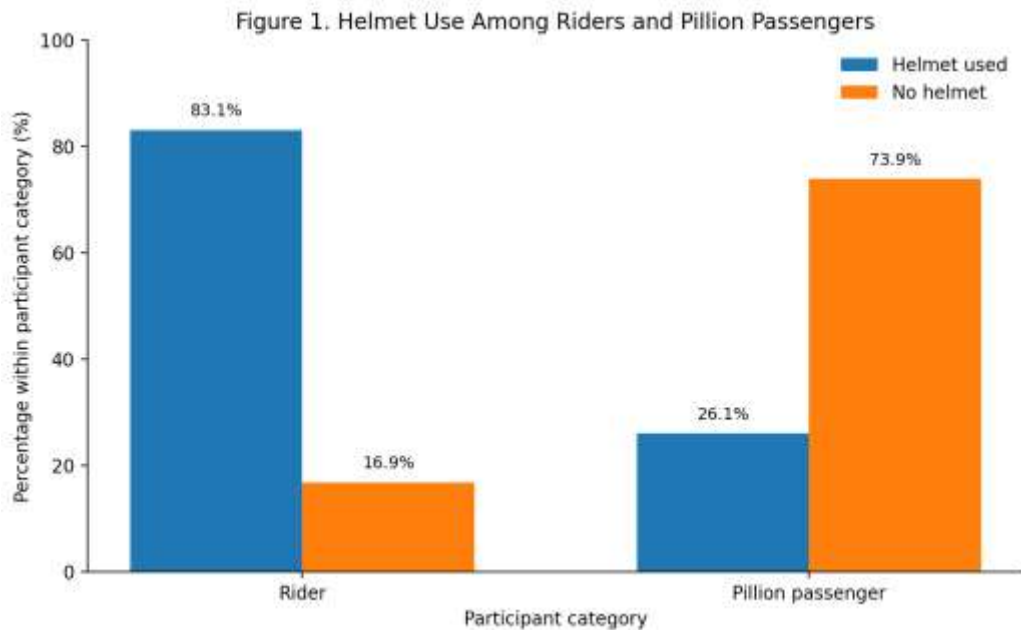
A total of 100 consecutive victims of two-wheeler road traffic accidents were included in the study. The majority were males (83%) and riders (77%). Helmet use was observed in 70% of participants, while 30% were not wearing helmets at the time of the accident. Most victims belonged to the >40 years age group (45%), followed by 20–30 years (28%).

Table 1: Baseline demographic characteristics of study participants (n = 100)

Variable		Frequency	Percentage (%)
Age (years)	<20	9	9.0
	20–30	28	28.0
	31–40	18	18.0
	>40	45	45.0
Sex	Male	83	83.0
	Female	17	17.0
Status	Rider	77	77.0
	Pillion	23	23.0

Helmet compliance was considerably higher among riders (83.1%) than pillion passengers (26.1%). Conversely, the majority of pillion passengers (73.9%) were not wearing helmets ($p < 0.001$). Helmet use was significantly higher among riders than pillion passengers.

Graph 1: Distribution of helmet use among riders and pillion passengers



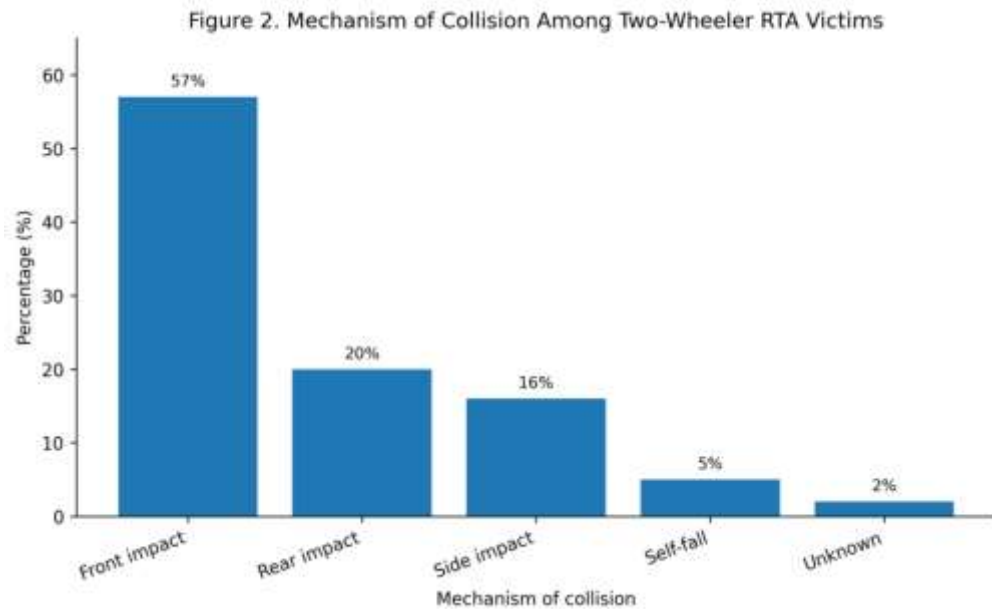
Helmet use was observed in 73.5% of males and 52.9% of females. Non-compliance was relatively higher among female participants ($p = 0.163$). Interpretation: No statistically significant association between gender and helmet use.

Table 2: Helmet use according to gender

Gender	Helmet	No Helmet	Total
Male	61	22	83
Female	9	8	17
Total	70	30	100

Front-impact collisions accounted for more than half (57%) of all accidents, followed by rear-end (20%) and side-impact collisions (16%).

Graph 2: Mechanism of collision



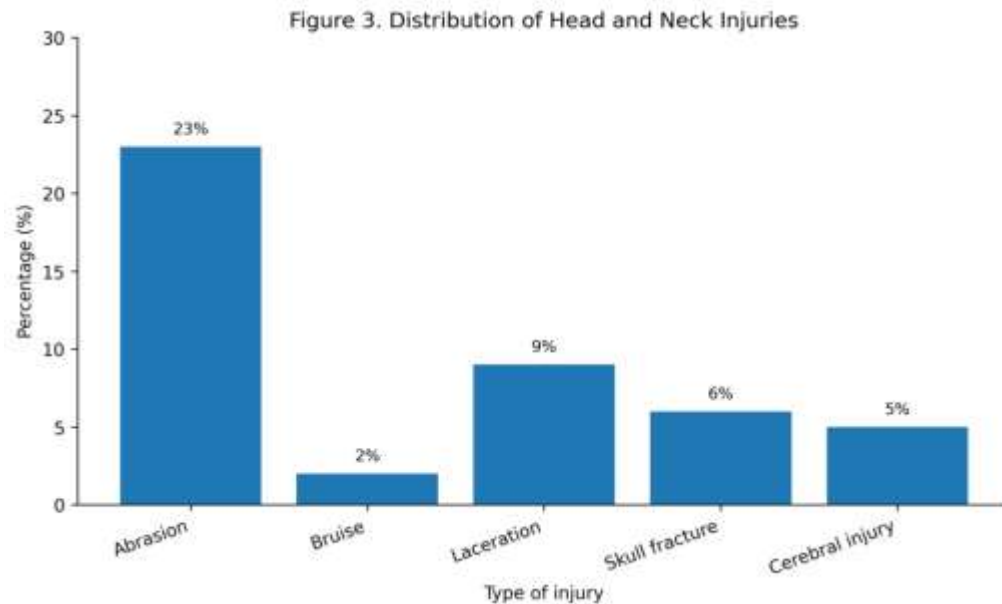
Abrasions represented the commonest injury in all anatomical regions. The upper limb (60%) and lower limb (50%) were the most frequently affected sites, while fractures predominated in the lower limbs (36%).

Table 3: Distribution of external injuries according to body region

Body Region	Abrasion	Bruise	Laceration	Fracture
Head & Neck	23	2	9	6
Thoraco-abdominal	20	1	0	2
Upper Limb	60	4	5	16
Lower Limb	50	10	17	36

Head and neck injuries were predominantly abrasions (23%), followed by lacerations (9%). Skull fractures (6%) and cerebral injuries (5%) were relatively less frequent, while bruises accounted for only 2%, indicating that superficial soft tissue injuries were more common than severe cranial trauma

Graph 3: Distribution of head and neck injury



Among upper limb fractures, fractures of the radius and ulna were the most common (n=6), followed by the humerus (n=5) and clavicle (n=4). In the lower limb, tibia and fibula fractures predominated (n=29), whereas femoral (n=9) and foot bone fractures (n=2) were comparatively less frequent, highlighting the lower extremity as the most commonly affected skeletal region.

Table 4: Distribution of upper and lower limb fractures

Fracture Site	Frequency
Upper Limb	
Clavicle	4
Humerus	5
Radius & Ulna	6
Hand bones	1
Lower Limb	
Femur	9
Tibia & Fibula	29
Foot bones	2

All 100 study participants survived following medical management, with no mortality recorded during the study period, resulting in an overall survival rate of 100%.

Table 5: Survival outcome

Outcome	Frequency	Percentage (%)
Survived	100	100.0

Outcome	Frequency	Percentage (%)
Died	0	0.0

DISCUSSION

The present prospective study demonstrated that helmet use was associated with a lower burden of severe head and neck injuries among two-wheeler road traffic accident victims. Although extremity injuries, particularly abrasions and lower-limb fractures, remained common, serious cranio-cerebral injuries were comparatively infrequent among helmet users. These findings reinforce the protective role of helmets in reducing injury severity and support their continued promotion as an effective public health intervention [10].

Male participants constituted the majority (83%) of accident victims, consistent with previous Indian studies reporting greater motorcycle usage, occupational travel, and risk-taking behaviour among men. Dandona R et al [11] and Sharma M, et al [12], similarly observed a marked male predominance among motorcycle crash victims, reflecting greater exposure to road traffic and higher riding frequency in India. The predominance of individuals aged over 40 years in the present study may be attributable to increased occupational commuting and prolonged daily road exposure.

Helmet compliance was significantly higher among riders than pillion passengers ($p < 0.001$), indicating poor adherence among passengers despite existing legislation. Comparable observations have been reported by Sinha et al [13] and Shool et al [14], who identified inadequate

enforcement, limited awareness, and misconceptions regarding pillion helmet use as major barriers to compliance. These findings highlight the need for stricter enforcement of helmet laws for both riders and passengers, accompanied by targeted public awareness campaigns.

Frontal-impact collisions accounted for more than half of all crashes (57%), representing the predominant mechanism of injury. Similar patterns have been reported in studies from India and other low- and middle-income countries, where head-on collisions commonly result from high vehicle density, excessive speed, unsafe overtaking, and poor lane discipline. Recognition of common collision mechanisms is important for planning preventive road safety strategies and improving traffic regulation [15, 16].

The injury pattern observed in this study showed that abrasions were the most frequent injuries, predominantly involving the upper and lower limbs, whereas fractures were most common in the lower extremities, particularly the tibia and fibula. This distribution is consistent with previous trauma studies demonstrating that while helmets effectively protect the head, they do not prevent extremity injuries because the limbs remain exposed during impact. These findings support the complementary use of other protective equipment, such as reinforced jackets, gloves, and knee guards, in addition to certified helmets [17, 18].

Head and neck injuries were relatively uncommon, with only 6% sustaining skull fractures and 5% cerebral injuries. Previous systematic reviews by Høye and Haut et al. have demonstrated that certified motorcycle helmets substantially reduce the risk of traumatic brain injury, skull fractures, and mortality by absorbing impact energy and reducing force transmission to the brain. The comparatively low frequency of severe cranial injuries observed in the present study is consistent with these established protective mechanisms [4, 19].

No mortality was observed among the study participants. Although the limited sample size and hospital-based design may partly explain this finding, early medical intervention, appropriate trauma management, and the relatively high prevalence of helmet use may also have contributed to the favourable outcomes. Larger multicentre studies are required to evaluate the effect of helmet use on mortality and long-term neurological outcomes.

Overall, the present study provides regional evidence that consistent helmet use significantly mitigates the severity of head injuries among two-wheeler accident victims while emphasizing the persistently low compliance among pillion passengers. Strengthening enforcement of universal helmet legislation, promoting the use of standard certified helmets, and implementing sustained road safety education programmes may substantially reduce the burden of preventable motorcycle-related injuries in India.

CONCLUSION

Helmet use was associated with a lower burden of severe head and neck injuries among victims of two-wheeler road traffic accidents, reaffirming its critical role in reducing injury severity. Although extremity injuries, particularly lower-limb fractures and abrasions, remained common, serious cranio-cerebral injuries were relatively infrequent among helmet users. Helmet compliance was significantly higher among riders than pillion passengers, highlighting an important gap in adherence to existing safety regulations. These findings underscore the need for stricter enforcement of universal helmet legislation, promotion of certified helmet use for both riders and pillion passengers, and sustained public awareness initiatives. Strengthening road safety policies and improving helmet compliance have the potential to substantially reduce preventable trauma, disability, and the overall healthcare burden associated with motorcycle-related road traffic accidents.

REFERENCES

1. World Health Organization. Global status report on road safety 2023. Geneva: World Health Organization; 2023.
2. Ministry of Road Transport and Highways. Road Accidents in India 2023. New Delhi: Ministry of Road Transport and Highways, Government of India; 2024.
3. Institute for Health Metrics and Evaluation. Global burden of road injuries 2021: findings from the Global Burden of Disease Study 2021. Seattle: IHME; 2024.
4. Høye A. Motorcycle helmets—To what extent do they reduce the risk of injuries? A

- meta-analysis. *Accid Anal Prev.* 2018; 117:85-97.
5. Wadhvaniya S, Gupta S, Tetali S, et al. The validity of self-reported helmet use among motorcyclists in India. *Inj Prev.* 2017;23(5):304-7.
6. Kengne AP, Monono ME, Sobngwi E, et al. Helmet use and injury outcomes among motorcycle crash victims: a systematic review and meta-analysis. *BMC Public Health.* 2022;22:1823.
7. Solagberu BA, Ofoegbu CK, Nasir AA, et al. Helmet use and injury severity among motorcycle crash victims in low- and middle-income countries: systematic review. *Inj Epidemiol.* 2021; 8:42.
8. Mishra B, Sinha ND, Sukhla SK, Sinha AK. Epidemiological study of road traffic accident cases from a tertiary care hospital in India: role of helmet use in reducing head injury severity. *J Family Med Prim Care.* 2021;10(5):2045-51.
9. Pathak SM, Jindal AK, Verma AK, Mahen A. An epidemiological study of road traffic accident cases admitted in a tertiary care hospital in North India with emphasis on helmet use and injury severity. *J Clin Diagn Res.* 2020;14(8):LC01-LC05.
10. Ranjbar H, Ahmadi A, et al. Effective factors of improved helmet use in motorcyclists: a systematic review. *BMC Public Health.* 2022;22:2415. doi:10.1186/s12889-022-14893-0.
11. Dandona R, Kumar GA, Ameer MA, et al. Incidence and burden of road traffic injuries in India. *Lancet Reg Health Southeast Asia.* 2023;12:100168.
12. Sharma M, Verma R, Singh P. Epidemiological profile and determinants of road traffic injuries among two-wheeler users in North India. *J Family Med Prim Care.* 2022;11(9):5351-5357.
13. Sinha V, Sharma D, et al. Helmet compliance and determinants among motorcycle users in urban India. *Indian J Community Med.* 2023;48(4):612-617.
14. Shool S, Piri SM, Ghodsi Z, et al. The prevalence of helmet use in motorcyclists around the world: A systematic review and meta-analysis. *Int J Inj Contr Saf Promot.* 2024;31(3):431-469
15. Azami-Aghdash S, Sadeghi-Bazargani H, et al. Effective factors of severity of traffic accident traumas based on the Haddon matrix: A systematic review and meta-analysis. *Chin J Traumatol.* 2024; 27:148-157.
16. Singh R, Gupta S, Sharma N. Predictors of head injury among motorcycle crash victims in a tertiary trauma centre. *Indian J Surg.* 2022;84(Suppl 2):1012-1018.
17. Seid M, Mebrahtu TF, Gebreslassie M, et al. Do motorcycle helmets reduce road traffic injuries, hospitalizations and mortalities in low- and lower-middle-income countries in Africa? A systematic review and meta-analysis. *BMC Public Health.* 2022;22:873. doi:10.1186/s12889-022-13138-4.
18. Chalya PL, Mabula JB, et al. Injury characteristics and outcomes of motorcycle crash victims: an updated review. *World J Emerg Surg.* 2021;16:38.
19. Haut ER, et al. Full-face motorcycle helmets to reduce injury and death: A systematic review, meta-analysis, and practice management guideline. *J Trauma Acute Care Surg.* 2023;94(2):e39-e47.