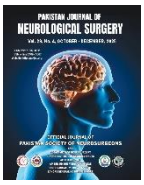

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Original Research

Neurological Outcomes and Helmet Use among Motorcyclists Admitted to a Tertiary Neurosurgical Center in Pakistan

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ABSTRACT

Objective: To determine neurological injury patterns, severity, outcomes, and helmet use prevalence among motorcyclists admitted to a tertiary neurosurgical unit.

Materials & Methods: This prospective cross-sectional study was conducted at Mardan Medical Complex from January to June 2025. Consecutive motorcycle crash victims with neurological injury requiring admission were enrolled. Data was collected using a structured questionnaire. Outcomes included injury type/severity (Glasgow Coma Scale: mild 13–15, moderate 9–12, severe ≤8), neurosurgical intervention, ICU admission, hospital stay, and mortality. Helmet use was documented. Data was analyzed descriptively.

Results: We enrolled 113 patients (mean age 26.9 ± 17.5 years; 85.0% male). Helmet use was 1.8% (n=2). Drivers comprised 62.8% and passengers 37.2%. Predominant diagnoses were traumatic brain injury (26.5%), extradural hematoma (15.9%), brain contusion (15.0%), and subarachnoid hemorrhage (14.2%). On admission, 69.0% had mild, 18.6% moderate, and 12.4% severe head injury. Conservative management was performed in 86.7% (n=98), and 13.3% (n=15) underwent surgery. ICU admission was required for 8.0% (n=9). Median hospital stay was 2 days (IQR 1–2). Overall mortality was 8.0% (n=9), all among non-helmeted riders. The two helmeted patients sustained only mild injuries, required no surgery or ICU care, and were discharged without complications.

Conclusion: Helmet use was rare but associated with milder injuries and zero mortality. Strengthened legislation, enforcement, and public education are urgently needed to reduce preventable neurotrauma.

Keywords: Helmet use; traumatic brain injury; motorcycle crash; neurosurgical outcomes; Pakistan.

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INTRODUCTION

Road traffic injuries (RTIs) remain one of the leading causes of death and disability worldwide,

disproportionately affecting low and middle-income countries (LMICs). Motorcyclists are particularly vulnerable, contributing substantially to trauma-related morbidity and mortality. Global helmet use remains suboptimal, estimated at ~48.7% in a meta-analysis of over five million participants, with especially low compliance reported from LMICs.[1,2]

According to the Global Burden of Disease 2021 report, road injuries continue to contribute substantially to disability and mortality, particularly in LMICs, with males aged 15–49 bearing a disproportionate burden.[3] Furthermore, the WHO Global Status Report on Road Safety 2023 estimates approximately 1.19 million annual road traffic deaths globally, with a large share among vulnerable users such as motorcyclists.[4]

In Pakistan, motorcycle crashes are a major contributor to traumatic brain injury (TBI) cases presenting to neurosurgical services. Several local studies have demonstrated the protective effect of helmets, with helmeted riders experiencing significantly lower mortality, fewer ICU admissions, and higher odds of presenting with mild GCS scores compared to unhelmeted riders.[5,6] These observations are supported by global systematic reviews, including the Cochrane review Helmets for preventing injury in motorcycle riders, which found helmet use reduces head injury risk by about 69% and mortality by ~42%.[7] The burden is especially high among young males, as shown in a large Southern Punjab trauma-center study where motorcyclists accounted for the majority of severe TBI admissions.[8]

Neurological injuries such as TBI, skull fractures, intracranial hemorrhage, and spinal trauma represent some of the most devastating consequences of motorcycle crashes, often resulting in long-term disability, increased healthcare costs, and lost productivity. Few studies in Pakistan have comprehensively characterized the spectrum and severity of these injuries among motorcyclists admitted to tertiary neurosurgical units, particularly in relation to helmet use. Existing reports from Peshawar and Lahore have described TBI severity distributions but often lacked reliable data on helmet compliance or reported extremely low usage rates.[9–11]

Helmet use is influenced by behavioral, regulatory, and socioeconomic factors. Stronger legislation, effective enforcement, helmet quality standards, and targeted public education improve compliance.[12,13] In Pakistan, barriers such as underage motorcycle driving, weak enforcement, cost, and poor public awareness remain significant obstacles.[14]

Given the significant burden of neurological injury among motorcyclists and persistently low helmet use in many Pakistani settings, there is a critical need to better define the types and severity of these injuries, their hospital course, and short-term outcomes. This study aims to address this gap by evaluating neurological injuries and outcomes among motorcyclists admitted to a tertiary neurosurgical center, as well as determining the prevalence of helmet use. The results may inform targeted policy, enforcement strategies, and public education initiatives aimed at reducing preventable neurological morbidity and mortality.

MATERIALS AND METHODS

Study Design and Setting

This prospective, hospital-based observational study was conducted at the Department of Neurosurgery, Mardan Medical Complex (a district-level tertiary referral centre), from January 1 to June 30, 2025.

Study Population

Consecutive patients presenting to the Accident & Emergency Department with neurological injuries following motorcycle crashes were screened.

Inclusion Criteria:

Inclusion criteria were: (1) motorcycle rider or pillion passenger, and (2) clinical or radiological evidence of neurological injury (traumatic brain

injury, intracranial hemorrhage, skull fracture) requiring hospital admission.

Exclusion Criteria:

Exclusion criteria were isolated non-neurological injuries, patients discharged directly from the emergency, incomplete medical records, or refusal to consent.

Sample Size

Using WHO's sample size calculator for cross-sectional studies with an assumed prevalence 50%, a precision of 10% and 95% confidence, the minimum sample size was 96. Allowing for 15% missing data, the target was ≥110 subjects; 113 consecutive eligible patients were enrolled.

Data Collection

A structured questionnaire (English → Pashto → back-translation) recorded demographics (age, sex), rider status (driver/pillion), number of passengers, helmet use at time of crash (helmet use was defined as wearing a helmet, as reported by the patient, an accompanying person, or the treating team on arrival), mode of arrival, admission and discharge GCS (classified as mild (13–15), moderate (9–12), or severe (≤8), radiological diagnoses (primarily based on non-contrast CT head in all cases, with MRI brain performed selectively when CT findings were equivocal or additional details were required), associated extracranial injuries, management (categorized as conservative or neurosurgical intervention, with the latter defined as any operative cranial procedure undertaken for trauma during the admission), ICU admission, length of hospital stay, discharge disposition (home, referral, death). Written informed consent was obtained; for unconscious patients, consent was provided by legal guardians.

Ethical Approval

Institutional Review Board of Mardan Medical Complex/Bacha Khan Medical College (Approval No. 839/BKMC). Data anonymized for analysis.

Statistical Analysis

Data was entered and analyzed using IBM SPSS Statistics v22. Continuous variables are reported as mean ± SD or median (IQR) as appropriate, and categorical variables as frequencies and percentages. Because only two patients were helmeted, comparisons by helmet status were descriptive; no inferential testing for helmeted vs non-helmeted subgroup comparisons was performed.

RESULTS

Patient Demographics and Crash Characteristics

A total of 113 patients were enrolled. The majority were male (85.0%) with a mean age of 26.9 ± 17.5 years; 45.1% were between 1–20 years. Drivers accounted for 62.8% of cases, while 37.2% were pillion passengers. Two-passenger motorcycles were most common (50.4%), followed by single riders (39.8%) and motorcycles carrying three or more passengers (9.7%). Helmet use was reported in only 2 patients (1.8%) (Table 1).

Radiological and Clinical Profiles

Traumatic brain injury (TBI) was the most frequent diagnosis (26.5%), followed by extradural hematoma (15.9%), brain contusion (15.0%), and subarachnoid hemorrhage (14.2%). Other diagnoses included linear skull fracture (9.7%), subdural hematoma (8.0%), depressed skull fracture (4.4%), pneumocephalus (3.5%), and brain parenchymal bleed (2.7%) (Table 2).

On admission, 69.0% of patients had mild head injury, 18.6% moderate, and 12.4% severe.

Management and Hospital Course

Conservative treatment was provided to 86.7% of patients (n=98), while 13.3% (n=15) underwent neurosurgical intervention. Intensive care admission was required in 9 patients (8.0%). The

median hospital stay was 2 days (IQR 1–2) (Table 3).

Table 1: *Demographics & crash characteristics (n = 113).*

Variable	n (%)
Sex	
Male	96 (85.0)
Female	17 (15.0)
Age groups	
1–20 years	51 (45.1)
21–40 years	35 (31.0)
41–60 years	23 (20.4)
>60 years	4 (3.5)
Mean age (SD)	26.9 ± 17.5 years
Helmet use	
Helmeted	2 (1.8)
Non-helmeted	111 (98.2)
Rider status	
Driver	71 (62.8)
Pillion passenger	42 (37.2)
Passengers per motorcycle	
Single rider	45 (39.8)
Two persons	57 (50.4)
≥3 persons	11 (9.7)

Table 2: *Radiological diagnosis (n = 113).*

Diagnosis	n (%)
Traumatic brain injury (TBI)	30 (26.5)
Extradural (epidural) hematoma	18 (15.9)
Brain contusion	17 (15.0)
Subarachnoid hemorrhage	16 (14.2)
Linear skull fracture	11 (9.7)
Subdural hematoma	9 (8.0)
Depressed skull fracture	5 (4.4)
Pneumocephalus	4 (3.5)
Brain parenchymal bleed	3 (2.7)

Table 3: *Summary of clinical severity, management, and outcomes (n = 113).*

Parameter	n (%)
Mild head injury (GCS 13–15)	78 (69.0)
Moderate head injury (GCS 9–12)	21 (18.6)
Severe head injury (GCS ≤8)	14 (12.4)
Conservative management	98 (86.7)
Surgical management	15 (13.3)
ICU admission	9 (8.0)
Median hospital stays	2 days (IQR 1–2)
In-hospital mortality	9 (8.0)

Outcomes

Overall, in-hospital mortality was 8.0% (n=9). All deaths occurred among non-helmeted riders. Both helmeted patients presented with mild head injury, required no surgical or ICU care, had short hospital stays, and were discharged without complications.

DISCUSSION

Motorcycle-related neurotrauma remains a major public health concern, particularly in low- and middle-income countries (LMICs), where motorcyclists contribute disproportionately to road traffic–related traumatic brain injuries (TBIs) and fatalities.[1,4] Our findings reaffirm that in our setting, the burden of severe morbidity and mortality is overwhelmingly borne by unhelmeted riders. Helmet use was extraordinarily rare (1.8%) in our cohort, and the two helmeted patients sustained only mild TBIs (GCS 13–15), required no surgical intervention, had shorter hospital stays, and experienced no mortality. In contrast, unhelmeted riders represented the entire spectrum of moderate-to-severe injuries, ICU admissions, neurosurgical procedures, and all in-hospital deaths. These findings reinforce global evidence that helmets are strongly protective against severe neurological injury and death.

Our results are consistent with both local and international literature showing that helmet use markedly reduces injury severity, ICU utilization, and mortality. A Karachi-based study of 400 head-injured patients found that helmeted riders had significantly lower ICU admission rates (35% vs. 51%), shorter hospital stays (median 5 vs. 10 days), and substantially lower mortality (7% vs. 25%) than unhelmeted counterparts.[5] Another cross-sectional study from Karachi in 2024–2025 reported that helmeted motorcycle riders presented predominantly with mild GCS (≈67%) compared with only ≈28% of non-helmeted riders, who had far higher rates of moderate and severe injuries.[6] Large multicenter data (≈270,000 motorcyclists) demonstrated that helmet use

halved the odds of sustaining severe head injury (AIS > 2) and independently reduced mortality risk.[15] Systematic reviews and meta-analyses further support this protective effect, reporting that helmets reduce the risk of death by ~45% and head/face injuries by ~57%, with less consistent effects on cervical spine injuries.[16,17] Biomechanically, helmets reduce kinetic energy transfer, limit skull deceleration, and protect against focal impacts, thus lowering the risk of skull fractures and intracranial hematomas [16,17].

In our series, TBI was the most frequent diagnosis, followed by extradural hematoma, brain contusions, subarachnoid hemorrhage, and skull fractures. Similar injury profiles have been reported in other regional studies. A Peshawar-based study of 156 motorcyclists reported contusions, extradural hematomas, cranial fractures, intracerebral bleeds, subdural hematomas, and traumatic subarachnoid hemorrhages as the most common findings.[9] Local studies that stratified by helmet status consistently show that unhelmeted riders sustain more radiologically severe injuries, require more neurosurgical interventions, and have longer ICU stays.[9,11,18] Cervical spine injuries, though less common, are more frequent and more severe in unhelmeted riders, adding further to their morbidity.[18]

The near absence of helmet usage in our sample is striking and substantially lower than even other Pakistani studies, where reported compliance ranges from 10–20% among injured motorcyclists and up to 50–60% in roadside observational surveys.[11,19] This rate is also far below the global prevalence of ≈48.7% and well under the levels recommended by WHO to achieve the UN Decade of Action for Road Safety 2021–2030 goals, which aim to halve road traffic deaths by 2030.[1,4] Low prevalence likely reflects weak enforcement of helmet legislation, limited public awareness, poor helmet availability, and sociocultural resistance. Systematic reviews highlight that socioeconomic status, enforcement rigor, helmet cost and quality, and knowledge of protective benefits are major determinants of compliance.[12,13]

Our in-hospital mortality rate of 8.0% (all unhelmeted) is slightly lower than the ≈13% mortality reported from Dera Ismail Khan, but remains unacceptably high given that most deaths were preventable.[11] Karachi-based studies similarly found higher mortality in non-helmeted patients despite comparable age and injury profiles.[5] Functional outcomes, although not formally assessed in our study, are expected to be poorer in unhelmeted patients, as previous research consistently shows helmet use is associated with better Glasgow Outcome Scores (GOS) and lower disability at discharge.[16,20]

Strengths of this study include prospective data collection, detailed radiological characterization, and inclusion of both riders and pillion passengers. However, limitations include the very small number of helmeted patients (n=2), which precluded formal hypothesis testing, the single-center design, and potential referral bias, as tertiary neurosurgical units may disproportionately receive severe injuries and underrepresent minor TBIs in the community. Long-term functional outcomes could not be assessed due to a lack of follow-up.

Implications

Our findings underscore the urgent need for a multisectoral strategy to improve helmet compliance. Strengthening helmet legislation, ensuring consistent enforcement, subsidizing the cost of certified helmets, and implementing culturally sensitive public awareness campaigns could dramatically reduce the neurosurgical and societal burden of motorcycle-related neurotrauma. The Eastern Association for the Surgery of Trauma guideline strongly recommends universal helmet use as a public health priority, and aligning national road safety initiatives with WHO targets should be considered a policy imperative.[4,17]

Public Health Implications

This study highlights the urgent need for coordinated public health interventions to enhance helmet compliance through stricter enforcement, subsidized helmet programs, and community-based education. Integrating road safety awareness into school curricula and strengthening primary prevention strategies can substantially reduce preventable neurotrauma and healthcare burden in Pakistan.

This study represents one of the few prospective analyses from Khyber Pakhtunkhwa exploring neurological outcomes and helmet compliance among motorcyclists.

CONCLUSION

Helmet use was exceedingly rare but clearly associated with milder injury and absence of ICU admission or in-hospital death in this cohort. Urgent multisectoral action, including stronger enforcement of helmet laws, measures to improve availability and affordability of certified helmets, and targeted public education, is required to reduce preventable motorcycle-related neurological morbidity and mortality.

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REFERENCES

1. Shool S., Piri SM., Ghodsi Z., et al. The prevalence of helmet use in motorcyclists around the world: a systematic review and meta-analysis of 5,006,476 participants. Int J Inj Contr Saf Promot. 2024;31:431–69. Doi: 10.1080/17457300.2024.2335509.
2. Abdi N., Robertson T., Petrucka P., Crizzle AM. 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;22:824. Doi: 10.1186/s12889-022-13138-4.
3. Wang K., Li Z. Global, regional, and national burdens of road injuries from 1990 to 2021: Findings from the 2021 Global Burden of Disease Study. Injury. 2025;56:112221. doi: 10.1016/j.injury.2025.112221.
4. Global status report on road safety 2023. Available at: https://www.who.int/teams/social-determinants-of-health/safety-and-mobility/global-status-report-on-road-safety-2023 [accessed September 17, 2025].
5. Ahmad S., Rehman L., Afzal A., Javeed F. Outcome of head injury in motorbike riders. Pak J Med Sci. 2023;39:390–4. Doi: 10.12669/pjms.39.2.6371.
6. Siddiqui MW., Gaziani MH., Ahmed Z. Frequency and Severity of Head Injury Among Motorcycle Riders With and Without Helmet Use. Biological and Clinical Sciences Research Journal. 2025;6:67–71. Doi: 10.54112/bcsrj.v6i5.1742.
7. Liu B., Ivers R., Norton R., Blows S., Lo SK. Helmets for preventing injury in motorcycle riders. Cochrane Database Syst Rev. 2004:CD004333. Doi: 10.1002/14651858.CD004333.pub2.
8. Rahman U., Hamid M., Shan Dasti M., Nouman T., Vedovelli L., Javid A. Traumatic Brain Injuries: A Cross-Sectional Study of Traumatic Brain Injuries at a Tertiary Care Trauma Center in the Punjab, Pakistan. Disaster Med Public Health Prep. 2022;17:e89. Doi: 10.1017/dmp.2021.361.
9. Zaman A., Ullah W., Ibrahim., Alam J., Ullah H. Pattern of Traumatic Brain Injuries and Their Frequencies in Motorcyclists. Pakistan Journal Of Neurological Surgery. 2024;28:357–63. Doi: 10.36552/pjns.v28i3.938.
10. Ali S., Mohsin M., Bajwa I. Six Months' Analysis of Head Injury due to Motor Bike Accidents in Punjab Institute of Neurosciences (PINS), Lahore. Pakistan Journal of Neurological Surgery. 2019;23:19–22.
11. Khan S., Nawaz S., Hayat F., Rehman S., Sardar N. Analysis of Head Injuries Due to Motorcycle Accidents Attended in Medical Teaching … 182 Institute (MTI), DHQ, Gomal Medical College (GMC), Dera Ismail Khan, Pakistan. Pakistan Journal OF Neurological Surgery. 2019;23:182–7. Doi: 10.36552/pjns.v23i3.357.
12. Mahdavi Sharif P., Najafi Pazooki S., Ghodsi Z., et al. Effective factors of improved helmet use in motorcyclists: a systematic review. BMC Public Health. 2023;23:26.

Doi: 10.1186/s12889-022-14893-0.
13. Ijaz M., Liu L., Al-Marhabi Y., Jamal A., Usman SM., Zahid M. Temporal Instability of Factors Affecting Injury Severity in Helmet-Wearing and Non-Helmet-Wearing Motorcycle Crashes: A Random Parameter Approach with Heterogeneity in Means and Variances. International Journal of Environmental Research and Public Health. 2022;19:10526. Doi: 10.3390/ijerph191710526.
14. Ashraf M., Kamboh UA., Hussain SS., et al. Traumatic Brain Injury in Underage Motorcycle Drivers: Clinical Outcomes and Sociocultural Attitudes from a Lower-Middle-Income Country. World Neurosurg. 2022;167:e413–22. Doi: 10.1016/j.wneu.2022.08.027.
15. Khor D., Inaba K., Aiolfi A., et al. The impact of helmet use on outcomes after a motorcycle crash. Injury. 2017;48:1093–7. Doi: 10.1016/j.injury.2017.02.006.
16. Koohi F., Soori H. Helmet Use and Its Efficacy on Preventing Motorcycle Injuries: A Systematic Review and Meta-analysis. Journal of Mazandaran University of Medical Sciences. 2019;28:198–216.
17. Urréchaga EM., Kodadek LM., Bugaev N., et al. Full-face motorcycle helmets to reduce injury and death: A systematic review, meta-analysis, and practice management guideline from the Eastern Association for the Surgery of Trauma. The American Journal of Surgery. 2022;224:1238–46. Doi: 10.1016/j.amjsurg.2022.06.018.
18. Shah SDBA., Riffat S., Wisal S., Asghar L., Janan H., Khan MA. Frequency and severity of Cervical spine injuries in motorcycle riders with and without helmet use. Journal of Pakistan Orthopaedic Association. 2020;32:13–7.
19. Khan I., Khan A., Aziz F., Islam M., Shafqat S. Factors associated with helmet use among motorcycle users in Karachi, Pakistan. Acad Emerg Med. 2008;15:384–7. Doi: 10.1111/j.1553-2712.2008.00049.x.
20. Choi WS., Cho J-S., Jang YS., Lim YS., Yang HJ., Woo J-H. Can helmet decrease mortality of craniocerebral trauma patients in a motorcycle accident? A propensity score matching. PLOS ONE. 2020;15:e0227691. Doi: 10.1371/journal.pone.0227691.

Additional Information

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Human Subjects: Consent was obtained from all patients/participants in this study.
Conflicts of Interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following:
Financial Relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.
Other Relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.
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AUTHOR CONTRIBUTIONS

Sr.#	Author's Full Name	Intellectual Contribution to the Paper in Terms of
1	**Musawer Khan**	Study design and methodology
2	**Shehzad Sadbar**	Data collection & calculations, literature review and referencing
3	**Muhammad Kamran**	Analysis of data and interpretation of results
4	**Salman Khan**	Data collection & calculations, literature review and referencing
5	**Waseem Sajjad**	Study design and methodology, paper writing, analysis of data and interpretation of results, editing and quality insurer
6	**Hira Imtiaz**	Data collection and calculations, literature review and referencing