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Original Article

Helmet Use, Injury Severity, And In-Hospital Mortality In Motorcycle-Related Head Trauma.

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Abstract

Objective: To evaluate the impact of helmet use on injury severity, radiological outcomes, and in-hospital mortality among patients presenting with motorcycle-related head trauma at a tertiary care setup in Dera Ghazi Khan, Pakistan.

Methodology: We conducted a prospective observational study in the Emergency and Neurosurgery Departments of DHQ Teaching Hospital, affiliated with DG Khan Medical College. The study duration was from June to December 2025. A total of 300 motorcycle riders and pillion passengers sustaining head trauma were enrolled. We analyzed the data using SPSS version 26. We used chi-square and independent t-tests, with $p < 0.05$ considered statistically significant.

Results: Of 300 patients, only 84 (28.0%) were wearing helmets at the time of the accident, while 216 (72.0%) were not. Non-helmeted riders had a significantly higher mean ISS (22.4 ± 6.1 vs. 11.2 ± 4.3, $p < 0.001$) and a higher prevalence of severe head injury (GCS 3-8) (41.2% vs. 8.3%, $p < 0.001$). In-hospital mortality was significantly higher in the non-helmeted group (16.7% vs. 2.4%, $p < 0.001$).

Conclusion: Helmet use significantly reduces injury severity and in-hospital mortality in motorcycle-related head trauma. The low compliance rate in DG Khan highlights an urgent need for strict traffic enforcement and public awareness campaigns.

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Introduction

Road traffic accidents (RTAs) remain a leading cause of morbidity and mortality globally, with low- and middle-income countries bearing the highest burden[1,2]. In Pakistan, motorcycles constitute the most common mode of transport, making motorcyclists highly vulnerable to severe trauma. According to the National Highways & Motorway Police and local health surveys, motorcycle-related RTAs account for over 60% of road traffic deaths in the country[3]. Traumatic brain injury (TBI) is the primary cause of death and long-term disability in these accidents, necessitating focused preventive strategies[4]. The use of protective helmets is universally recognized as the most effective intervention to mitigate head injuries in motorcycle crashes. Biomechanically, helmets absorb impact energy, reduce the acceleration transmitted to the brain, and prevent direct skull penetration[5]. Despite this, helmet compliance in Pakistan remains suboptimal, particularly in rural and semi-urban areas like South Punjab. Cultural norms, weak law enforcement, and the misconception that helmets cause cervical spine injuries or discomfort in hot weather contribute to low usage rates[6,7]. Furthermore, while drivers occasionally wear helmets, pillion riders rarely do, leaving a massive demographic unprotected[8,9]. While national data provides a broad overview, localized epidemiological data is crucial for designing region-specific public health interventions. Dera Ghazi Khan (DG Khan), a major city in South Punjab, has seen a rise in RTAs due to increased traffic volume and inadequate enforcement of safety regulations. However, recent localized scientific literature quantifying the impact of helmet use on clinical outcomes in this demographic remains limited [10]. Therefore, this study was conducted at DG Khan Medical College to determine the association between helmet use, injury severity, and in-hospital mortality in patients with motorcycle-related head trauma, aiming to provide evidence-based recommendations for local traffic safety policies.

Material and Methods

This prospective observational cohort study was conducted in the Emergency Department and Neurosurgery Unit of DHQ Teaching Hospital, the primary tertiary-care training hospital affiliated with DG Khan Medical College, Dera Ghazi Khan, Pakistan. Study Duration: The study was conducted over seven months, from June 1, 2025, to December 31, 2025. Sample Size and Sampling Technique: Using a non-probability consecutive sampling technique, we enrolled 300 patients. The sample size was calculated based on the expected prevalence of severe TBI in non-helmeted riders (approx. 35%) with a 95% confidence level and a 5% margin of error. Inclusion and Exclusion Criteria: All patients (both drivers and pillion riders) aged 15 years and above who sustained head trauma in a motorcycle accident and were brought to the emergency department. *Exclusion criteria:* Patients involved in non-motorcycle RTAs (e.g., cars, pedestrians), patients with unknown helmet-use status, patients who were dead on arrival (DOA), and those with incomplete medical records or who left against medical advice (LAMA) within 24 hours. Data Collection and Variables: We designed a structured proforma to collect demographic data (age, gender, riding role), pre-hospital data (helmet-use status, defined as wearing a standard helmet properly fastened at the time of impact), and clinical data. We assessed injury severity using the Glasgow Coma Scale (GCS) at the time of emergency admission, categorizing TBI as mild (13-15), moderate (9-12), or severe (3-8). We calculated the Injury Severity Score (ISS) using the Abbreviated Injury Scale (AIS) for all body regions; we defined ISS ≥ 16 as severe trauma. We determined radiological outcomes using non-contrast CT scans of the brain. The primary outcome measure was in-hospital mortality. We entered and analyzed data using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Quantitative variables (age, ISS) were expressed as mean ± standard deviation and compared using an independent-samples t-test. Qualitative variables (helmet use, GCS categories, CT findings, mortality) were expressed as frequencies and percentages and compared using the Chi-square test or Fisher's exact test where appropriate. We used multivariate logistic regression to identify independent predictors of mortality. We considered $p < 0.05$ statistically significant.

Results

A total of 300 patients with motorcycle-related head trauma were included in the study. Of these, 84 (28.0%) were wearing helmets at the time of the accident, whereas 216 (72.0%) were not. Demographically, most patients were aged 15–25 years (42.0%), followed by those aged 26–35 years (39.3%). Male patients constituted 96.0% of the study population. A significant association was observed between riding role and helmet use: 85.7% of helmeted patients were motorcycle drivers, whereas only 14.3% were pillion riders ($p < 0.001$), as shown in Table 1. Neurological assessment at admission revealed significantly greater injury severity among non-helmeted patients. Severe traumatic brain injury (GCS 3–8) was observed in 41.2% of non-helmeted patients compared with 8.3% of helmeted patients ($p < 0.001$). Similarly, severe trauma (ISS ≥16) was significantly more frequent among non-helmeted patients (65.7%) than among helmeted patients (19.0%). The mean Injury Severity Score was also significantly higher in the non-helmeted group (22.4 ± 6.1) compared with the helmeted group (11.2 ± 4.3; $p < 0.001$), as shown in Table 2. CT brain imaging showed significantly different injury patterns between the two groups. Normal or mild cerebral contusion was observed in 50.0% of helmeted patients compared with 17.6% of non-helmeted patients. In contrast, epidural or subdural hematomas were more frequent among non-helmeted patients (31.5% vs. 16.7%). Diffuse axonal injury or brainstem involvement was also considerably higher in non-helmeted patients (17.6% vs. 4.8%). Table 3 summarizes these findings. Regarding in-hospital clinical outcomes, non-helmeted patients demonstrated significantly higher rates of complications and intensive care requirements. ICU admission was required in 54.6% of non-helmeted patients compared with 14.3% of helmeted patients. Similarly, mechanical ventilation was required in 29.6% versus 4.8%, and neurosurgical intervention in 35.2% versus 9.5%, respectively. In-hospital mortality was also significantly higher among non-helmeted patients (16.7%) than among helmeted patients (2.4%; $p < 0.001$), as detailed in Table 4. Multivariate logistic regression identified helmet use as an independent protective factor against in-hospital mortality. After adjustment for age, Glasgow Coma Scale, and Injury Severity Score, helmet use was associated with significantly lower odds of mortality (OR = 0.21, 95% CI: 0.07–0.65, $p = 0.004$). Conversely, severe traumatic brain injury (GCS 3–8) was associated with increased odds of mortality (OR = 8.74,

95% CI: 4.12–18.54, p < 0.001), while severe injury (ISS ≥16) was also an independent predictor of mortality (OR = 5.32, 95% CI: 2.45–11.56, p < 0.001). Age above 35 years was not significantly associated with mortality after adjustment (p = 0.198). Table 5 presents these findings.

Table 1: Demographic characteristics and helmet use status among motorcycle trauma patients (N=300)

Variable	Category	Helmeted (n=84)	Non-Helmeted (n=216)	Total (N=300)	p-value
Age (Years)	15 - 25	32 (38.1%)	94 (43.5%)	126 (42.0%)	0.412
	26 - 35	36 (42.9%)	82 (38.0%)	118 (39.3%)	
	> 35	16 (19.0%)	40 (18.5%)	56 (18.7%)	
Gender	Male	81 (96.4%)	207 (95.8%)	288 (96.0%)	0.825
	Female	3 (3.6%)	9 (4.2%)	12 (4.0%)	
Riding Role	Driver	72 (85.7%)	102 (47.2%)	174 (58.0%)	< 0.001
	Pillion Rider	12 (14.3%)	114 (52.8%)	126 (42.0%)	

Age and gender distributions were similar between the two groups (p > 0.05); the riding role showed a highly significant association with helmet use (p < 0.001). Drivers were significantly more likely to wear helmets (85.7%) compared to pillion riders, of whom only 14.3% were helmeted.

Table 2: Distribution of Injury Severity Score (ISS) and Glasgow Coma Scale (GCS) based on helmet use

Clinical Parameter	Category	Helmeted (n=84)	Non-Helmeted (n=216)	p-value
GCS at Admission	Mild (13-15)	58 (69.0%)	62 (28.7%)	< 0.001
	Moderate (9-12)	19 (22.6%)	65 (30.1%)	
	Severe (3-8)	7 (8.3%)	89 (41.2%)	
Injury Severity Score	Minor/Moderate (<16)	68 (81.0%)	74 (34.3%)	< 0.001
	Severe (≥ 16)	16 (19.0%)	142 (65.7%)	
Mean ISS (± SD)		11.2 ± 4.3	22.4 ± 6.1	< 0.001

Non-helmeted patients had a significantly worse neurological status at admission, with 41.2% presenting with severe TBI (GCS 3-8) compared to only 8.3% in the helmeted group (p < 0.001).

Table 3: Radiological findings (CT Brain) in helmeted vs. non-helmeted riders

CT Brain Findings	Helmeted (n=84)	Non-Helmeted (n=216)	p-value
Normal / Mild Contusion	42 (50.0%)	38 (17.6%)	< 0.001
Skull Fracture (Linear/Depressed)	24 (28.6%)	72 (33.3%)	
Epidural / Subdural Hematoma	14 (16.7%)	68 (31.5%)	
Diffuse Axonal Injury / Brainstem	4 (4.8%)	38 (17.6%)	

Helmeted riders had a significantly higher proportion of normal or mildly injured brains (50.0%) compared to non-helmeted riders (17.6%). Conversely, life-threatening intracranial pathologies, specifically Diffuse Axonal Injury (DAI) and brainstem injuries, were markedly higher in the non-helmeted group (17.6% vs. 4.8%).

Table 4: In-hospital clinical outcomes and mortality based on helmet use

Clinical Outcome	Helmeted (n=84)	Non-Helmeted (n=216)	p-value
ICU Admission	12 (14.3%)	118 (54.6%)	< 0.001
Mechanical Ventilation	4 (4.8%)	64 (29.6%)	< 0.001
Neurosurgical Intervention	8 (9.5%)	76 (35.2%)	< 0.001
In-Hospital Mortality	2 (2.4%)	36 (16.7%)	< 0.001

Non-helmeted patients required significantly more intensive care, including ICU admission (54.6% vs. 14.3%), mechanical ventilation (29.6% vs. 4.8%), and neurosurgical interventions (35.2% vs. 9.5%) (all p < 0.001). Most importantly, in-hospital mortality was 16.7% in the non-helmeted group compared with 2.4% in the helmeted group, a highly significant difference (p < 0.001) that underscores the life-saving role of helmets.

Table 5: Multivariate logistic regression analysis for predictors of in-hospital mortality

Predictor Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Age (> 35 years)	1.45	0.82 - 2.56	0.198
Helmet Use (Yes vs. No)	0.21	0.07 - 0.65	0.004
GCS (Severe 3-8 vs. Mild)	8.74	4.12 - 18.54	< 0.001
ISS (≥ 16 vs. < 16)	5.32	2.45 - 11.56	< 0.001

After adjusting for age, initial GCS, and ISS, helmet use emerged as a significant independent protective factor against mortality (OR = 0.21, 95% CI: 0.07-0.65, p = 0.004). This means that wearing a helmet reduced the odds of dying in the hospital by nearly 79%. Conversely, severe GCS and high ISS were strong independent predictors of mortality (p < 0.001), while age was not a statistically significant independent predictor in this adjusted model.

Discussion

This prospective study conducted at DG Khan Medical College evaluated the critical role of helmet use in mitigating injury severity and mortality in motorcycle-related head trauma. The findings unequivocally demonstrate that helmeted riders suffer significantly less severe brain injuries and have a drastically lower in-hospital mortality rate compared to their non-helmeted counterparts[11]. Overall helmet compliance in our study was alarmingly low at 28.0%. This figure is consistent with recent national data from Pakistan, which reports helmet usage rates between 20% and 35% in semi-urban and rural settings [12]. A striking finding in our study was the disparity in helmet use between drivers and pillion riders; while 85.7% of drivers wore helmets, only 14.3% of pillion riders did. This reflects a deep-rooted cultural and behavioral trend in South Punjab, where drivers may wear helmets to avoid traffic fines. However, pillion riders (often family members) remain unprotected because of weak social norms and enforcement [13]. Similar findings were reported by a 2023 study from Multan, which highlighted that pillion riders are at a disproportionately higher risk of fatal TBI [14,15]. The clinical outcomes in our study strongly corroborate the biomechanical advantages of helmets. Non-helmeted patients had a mean ISS of 22.4, placing them in the severe trauma category, compared to 11.2 in helmeted patients. Radiologically, non-helmeted riders had a significantly higher incidence of Diffuse Axonal Injury (DAI) and large hematomas. This aligns with a 2022 systematic review by Ali et al., which concluded that helmet use reduces the risk of severe TBI by approximately 60% and fatal injuries by 40% in the South Asian demographic[16,17]. In-hospital mortality in our non-helmeted group was 16.7%, compared with 2.4% in the helmeted group. Multivariate analysis confirmed that helmet use independently reduced the odds of mortality by 79% (OR = 0.21), mirroring global data from the WHO and recent studies from neighboring India [18,19]. Despite the clear evidence, the low compliance rate in DG Khan poses a significant public health challenge. The local traffic police face logistical and cultural hurdles in enforcing helmet laws, particularly for pillion riders. Furthermore, substandard, non-certified helmets available in local markets provide a false sense of security because they fail to absorb critical impact energy[20,21]. This study was conducted at a single tertiary care center, which may introduce selection bias, as severe cases are often referred here from surrounding rural areas. Additionally, we could not assess long-term neurological and functional outcomes in survivors after discharge. Future multi-center studies with long-term follow-ups are recommended.

Conclusion

Helmet use is a highly effective, independent protective factor against severe traumatic brain injury and in-hospital mortality in motorcycle-related accidents. The current study from DG Khan reveals a critically low helmet compliance rate, especially among pillion riders, which directly translates to higher injury severity and increased mortality. The local administration and traffic police in Dera Ghazi Khan urgently need to enforce strict helmet laws for both drivers and pillion riders, alongside public awareness campaigns and the provision of standardized, certified helmets, to reduce the devastating burden of road traffic trauma.

Ethical approval

The Institutional Review Board (IRB) of DG Khan Medical College granted ethical approval **(Ref No: DGKMC/IRB/2025/112).** We obtained informed verbal consent from patients or their legal attendants, in line with standard protocol for observational trauma studies in the emergency setting.

Informed Consent

We obtained written informed consent from all participants before enrolment. We informed participants and their parents or legal guardians about the study objectives, procedures, and the voluntary nature of participation. Participation was entirely voluntary.

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This study received no external funding and used available institutional resources.

Conflict of Interest

The authors declare no competing interests or conflicts of interest related to this study.

Authors' Contributions

Atta-Ur-Rehman Khan: Contributed to conceptualization, study design, data collection, interpretation of findings, manuscript drafting, critical revision, and final approval. He also accepts accountability for all aspects of the work.

Syed Aushtar Abbas Naqvi, Sarwat Rasheed: Contributed to study design, data collection, data curation, literature review, interpretation of data, manuscript revision, and final approval of the manuscript. He also accepts accountability for all aspects of the work.

Tayyaba Shakeel, Usama Ahmad, Muhammad Ahsan Ali: Contributed to conceptualization, study supervision, clinical assessment, interpretation of findings, and critical revision of the manuscript for important intellectual content. She also approved the final version and accepts accountability for all aspects of the work.

All authors: Reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work in accordance with the **ICMJE** authorship criteria.

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