ORIGINAL ARTICLE

Evaluation of the Impact of Helmet Use on the Severity of Traumatic Brain Injury

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ABSTRACT

Introduction: Traumatic brain injuries are a leading cause of morbidity and mortality among motorcyclists, especially in Nepal, where two-wheeler vehicles are highly prevalent. This study investigates the association between helmet use and the severity of traumatic brain injuries in motorcyclists presenting to a tertiary care hospital. **Aims:** To evaluate the impact of helmet use on the severity of traumatic brain injuries and associated clinical outcomes. **Methods:** A prospective cohort study was conducted on 150 motorcyclists admitted to Kathmandu Medical College Teaching Hospital between July and September 2023. Data on demographic and clinical characteristics, including age, gender, mechanism of injury, alcohol or drug use, and injury severity, were collected. The Glasgow Coma Scale scores and imaging findings were analyzed to assess traumatic brain injury severity. Statistical tests, including chi-square and logistic regression, were employed to evaluate the association between helmet use and injury outcomes. **Results:** Among 150 participants, 87 (58%) were helmeted, and 63 (42%) were non-helmeted. The mean age was 32.8 years (SD = 11.2). Helmeted patients had significantly higher Glasgow Coma Scale scores (13.2 vs. 8.4, $p < 0.001$) and were more likely to experience mild or moderate traumatic brain injuries (90%) compared to non-helmeted patients, who had a higher proportion of severe injuries (60%). Imaging revealed that helmeted patients had a lower incidence of intracranial hemorrhage (25% vs. 75%) and contusions (15% vs. 60%) ($p < 0.001$). **Conclusion:** Helmet use significantly reduces the severity of traumatic brain injuries, as evidenced by higher Glasgow Coma Scale scores, lower intracranial hemorrhage rates and reduced likelihood of severe injuries. These findings emphasize the need to promote helmet use to mitigate the burden of traumatic brain injuries in Nepal.

Keywords: Traumatic brain injury, helmet use, Glasgow Coma Scale, motorcyclists, Nepal, injury prevention

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INTRODUCTION

Traumatic brain injury (TBI) is a major public health issue worldwide, including in Nepal, where it is a leading cause of morbidity and mortality. Road traffic accidents, particularly involving motorcyclists, are a primary cause of TBI due to the high prevalence of two-wheelers. Helmet use is widely recognized as an effective measure to reduce the severity of head injuries.[1,2] Helmets are designed to absorb impact energy and protect the skull and brain. Studies have shown that helmet use significantly decreases the risk of head injury and fatality among motorcyclists.[3,4] Despite mandatory helmet laws in Nepal, compliance varies, and the quality and fit of helmets are often suboptimal.[5] Additionally, awareness and attitudes towards helmet use can influence the effectiveness of this intervention. The effectiveness of helmets in reducing TBI severity, particularly in the context of Nepal's unique traffic conditions, remains under-explored.This study evaluates the impact of helmet use on the severity of TBI among motorcyclists admitted to Kathmandu Medical College Teaching Hospital. By analyzing helmet use prevalence, TBI severity, and clinical outcomes such as Glasgow Coma Scale scores and intracranial injuries, the findings aim to provide critical insights into the effectiveness of current policies and identify strategies for improving helmet compliance. These findings will inform public health initiatives to reduce the burden of TBI in Nepal.

METHODS

This prospective cohort study was conducted to evaluate the impact of helmet use on the severity of traumatic brain injury (TBI) among patients treated at Kathmandu Medical College Teaching Hospital (KMCTH) from July to September 2023. The study design enabled real-time data collection on helmet use and TBI severity, minimizing recall bias and enhancing the reliability of the findings. The study included individuals aged 18 years and above who sustained TBIs while traveling on motorcycles and sought treatment at the Neurosurgical Outpatient Department (NSOPD) or the Department of Emergency Medicine at KMCTH. Inclusion criteria required participants to have a confirmed diagnosis of TBI based on clinical and imaging findings. Patients with pre-existing neurological conditions or who refused to provide informed consent were excluded. The research was conducted at the Neurosurgery OPD (NSOPD) and the Department of Emergency Medicine at KMCTH, a major neurosurgical center in Kathmandu, Nepal. Data were collected through a combination of medical record reviews, patient interviews and direct observations.

1. Medical Record Review: Detailed information was extracted from patient medical records, including demographic data, mechanism of injury, helmet use at the time of the incident, clinical assessments, imaging findings, and treatment details.

2. Patient Interviews: Semi-structured interviews were conducted with patients to gather additional information about the circumstances of the injury and their helmet use behavior.

3. Clinical Assessments: The severity of TBI was assessed using the Glasgow Coma Scale (GCS) and imaging studies (CT or MRI scans) to identify the presence and extent of intracranial hemorrhage or contusions.

Variables

• Dependent Variable: The severity of TBI, assessed using the GCS, presence of intracranial hemorrhage, and contusions on imaging.

• Independent Variable: Helmet use at the time of injury, categorized as helmeted or non-helmeted.

• Additional Variables: Age, gender, mechanism of injury, and alcohol or drug use at the time of injury were recorded to account for potential confounding factors.

Data Collection Tools

i. Structured Data Collection Form: A form was developed to systematically capture demographic information, injury characteristics, helmet use details and TBI severity indicators.

ii. Helmet Use Questionnaire: This tool gathered specific details about helmet use, including type, frequency, duration and reasons for non-use.

iii. Glasgow Coma Scale (GCS): This clinical tool was used to evaluate the severity of TBI based on the patient's level of consciousness, motor responses and eye-opening.

Data were cleaned, validated, and analyzed using appropriate statistical methods. Descriptive statistics were used to summarize demographic and clinical characteristics. Inferential statistics, including chi-square tests and logistic regression, were employed to assess the association between helmet use and TBI severity while controlling for potential confounding variables. Ethical approval was obtained from the Institutional Review Board (IRB) of KMCTH, ensuring compliance with ethical standards. Confidentiality and privacy of the participants were maintained, and informed consent was obtained from all participants prior to data collection. Regular monitoring and cross-verification of collected data were conducted to maintain accuracy and completeness.

RESULTS

A total of 150 patients were included in the study, with 90 (60%) being male and 60 (40%) female. The mean age of the participants was 32.8 years (SD = 11.2), ranging from 18 to 65 years. Of the 150 patients, 87 (58%) were helmeted at the time of the injury, while 63 (42%) were not.

Characteristic	Helmeted (n=87)	Non-Helmeted (n=63)	Total (n=150)	p-value
Age (years)				
Mean (SD)	33.5 (10.8)	32.0 (11.5)	32.8 (11.2)	0.42
Range	18-65	18-65	18-65	
Gender				
Male	54 (62.1%)	36 (57.1%)	90 (60%)	0.55
Female	33 (37.9%)	27 (42.9%)	60 (40%)	0.55
Mechanism of Injury				
Collision	66 (75.9%)	46 (73.0%)	112 (75%)	0.72
Fall/Other	21 (24.1%)	17 (27.0%)	38 (25%)	0.72
Alcohol/Drug Use				
Yes	15 (17.2%)	15 (23.8%)	30 (20%)	0.30
No	72 (82.8%)	48 (76.2%)	120 (80%)	0.30

Table I: Demographic and Clinical Characteristics of Study Participants

Below is a pie chart (Figure 1) indicating that 25% of participants were under the influence of alcohol or drugs at the time of injury, while 75% were not.

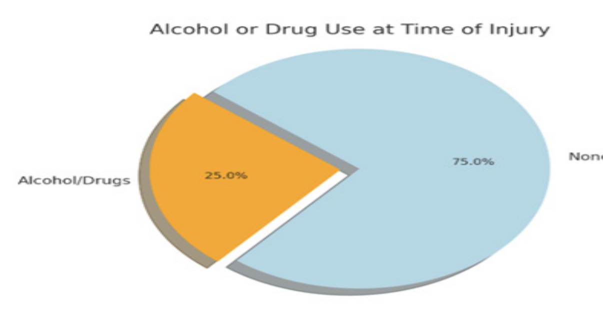

Figure 1: Alcohol or Drug Use at Time of Injury

Injury Mechanism and Helmet Use

The majority of injuries (75%) resulted from direct collisions with other vehicles, while the remaining 25% were due to loss of control or skidding. Alcohol or drug use at the time of injury was reported by 20% of the participants. Among those who used helmets, 68% reported wearing full-face helmets, and 32% wore half-face helmets.

TBI Severity	Helmeted (n=87)	Non-Helmeted (n=63)	Total (n=150)	p-value
Mild (GCS 13-15)	78 (89.7%)	30 (47.6%)	108 (72%)	<0.001
Moderate (GCS 9-12)	7 (8.0%)	18 (28.6%)	25 (16.7%)	<0.001
Severe (GCS 3-8)	2 (2.3%)	15 (23.8%)	17 (11.3%)	<0.001

Table II: Helmet Use and TBI Severity

Table II shows the distribution of TBI severity among helmeted and non-helmeted riders. Chi-square tests were used to determine the significance of differences in TBI severity.

TBI Severity

Glasgow Coma Scale (GCS) Scores

The GCS scores ranged from 3 to 15, with a mean score of 11.5 (SD = 3.2). Helmeted patients had a significantly higher mean GCS score (13.2, SD = 2.1) compared to non-helmeted patients (8.4, SD = 3.7) ($p < 0.001$).

• **Mean GCS Score by Helmet Use**: This bar chart (Figure 2) shows the difference in mean GCS scores between helmeted and non-helmeted patients. Helmeted patients have a higher mean GCS score (13.2) compared to non-helmeted patients (8.4), indicating less severe TBIs in helmeted individuals.

• **TBI Severity by Helmet Use:** This stacked bar chart (Figure 3) compares the severity of TBIs between helmeted and non-helmeted patients. Helmeted individuals mostly experienced mild/moderate TBIs (90%), while a higher percentage of non-helmeted patients suffered from severe TBIs (60%).

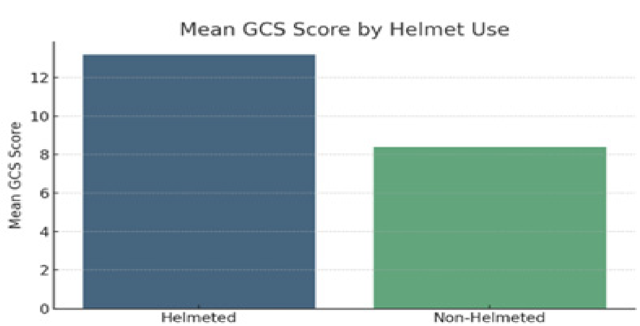

Figure 2: Mean GCS score by helmet use

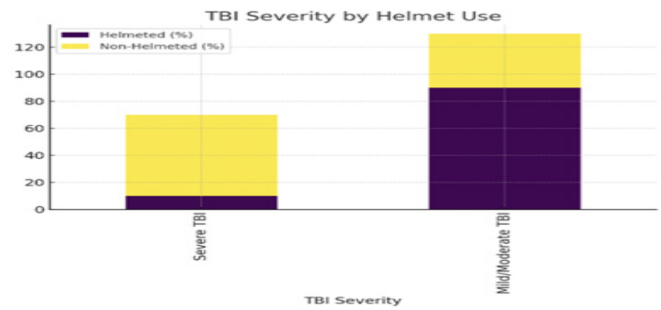

Figure 3: TBI severity by helmet use

Intracranial Hemorrhage and Contusions

Imaging studies revealed that 45% of the patients had intracranial hemorrhage, and 30% had contusions. Among helmeted patients, 25% had intracranial hemorrhage and 15% had contusions. In contrast, 75% of non-helmeted patients had intracranial hemorrhage, and 60% had contusions. The difference in the incidence of intracranial hemorrhage and contusions between helmeted and non-helmeted patients was statistically significant ($p < 0.001$).

• Intracranial Hemorrhage by Helmet Use: This bar chart (Figure 4) illustrates the percentage of patients with intracranial hemorrhage among helmeted and non-helmeted individuals. A significantly higher percentage of non-helmeted patients (75%) experienced intracranial hemorrhage compared to helmeted patients (25%).

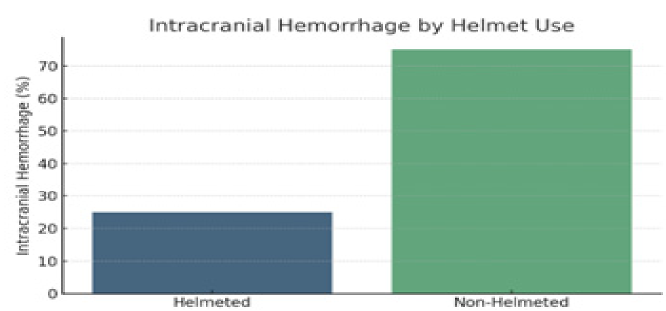

Figure 4: Intracranial hemorrhage by helmet use

• Contusions by Helmet Use: This bar chart (Figure 5) displays the percentage of patients with contusions among helmeted and non-helmeted individuals. Non-helmeted patients (60%) had a higher incidence of contusions compared to helmeted patients (15%).

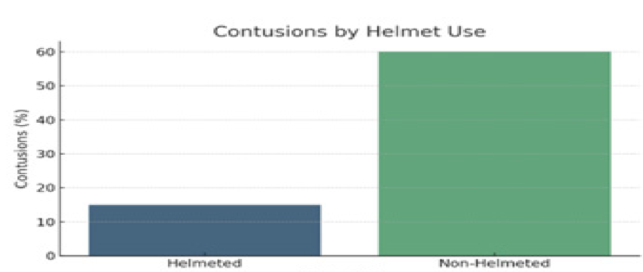

Figure 5: Contusion by helmet use

Statistical Analysis

Chi-square tests indicated a significant association between helmet use and TBI severity. Helmeted patients were less likely to suffer severe TBIs (GCS ≤ 8) compared to non-helmeted patients ($\chi^2 = 28.6$, $p < 0.001$).

Logistic regression analysis, controlling for age, gender, mechanism of injury, and alcohol or drug use, demonstrated that helmet use was a significant protective factor against severe TBI (OR = 0.25, 95% CI: 0.13-0.48, $p < 0.001$). Other significant predictors of TBI severity included alcohol or drug use (OR = 2.5, 95% CI: 1.1-5.7, $p = 0.03$).

Variable	Odds Ratio (95% CI)	p-value
Helmet Use	0.25 (0.13-0.48)	<0.001
Age	1.01 (0.98-1.05)	0.42
Gender (Male)	0.85 (0.42-1.71)	0.65
Alcohol/Drug Use	2.50 (1.10-5.68)	0.03
Mechanism of Injury	1.20 (0.60-2.40)	0.62

Table III: Logistic Regression Analysis of Factors Associated with Severe TBI

Table III presents the logistic regression analysis to identify factors associated with severe TBI. The odds ratios (OR) and 95% confidence intervals (CI) were calculated, adjusting for age, gender, mechanism of injury, and alcohol or drug use. The p-values indicate the significance of each factor in predicting severe TBI.

This study highlighted the significant protective effect of helmet use on the severity of TBIs among motorcyclists. Helmeted individuals had higher GCS scores, lower incidence of intracranial hemorrhage and contusions, and reduced likelihood of severe TBI. These findings underscore the importance of promoting helmet use to reduce the burden of TBIs in Nepal.

DISCUSSION

This study aimed to evaluate the impact of helmet use on the severity of traumatic brain injury (TBI) among patients treated at Kathmandu Medical College Teaching Hospital (KMCTH) from July to September 2023. Our findings provide valuable insights into the protective effects of helmet use in a lower-middle-income country context, which has significant implications for public health and injury prevention strategies.

Our analysis demonstrated that helmeted riders had significantly lower TBI severity compared to non-helmeted riders, as evidenced by higher Glasgow Coma Scale (GCS) scores and reduced incidences of intracranial hemorrhages and contusions. These results are consistent with numerous studies that have established the efficacy of helmets in mitigating the impact of head injuries in motorcycle accidents.[1,6,7] Helmets act as a mechanical barrier, absorbing and dissipating the energy of a collision, thereby reducing the force transmitted to the skull and brain.[3] A comprehensive review by Liu et al highlighted that helmet use reduces the risk of head injury by approximately 69% and the risk of death by 42%.[8]

The study population predominantly consisted of young males, which aligns with global epidemiological data indicating that young men are at a higher risk of motorcycle-related TBIs.[9,10] This demographic trend underscores the need for targeted interventions to promote helmet use and safe riding practices among this high-risk group. Additionally, alcohol or drug use at the time of injury was recorded in a significant proportion of patients, highlighting the role of substance use in exacerbating the risk of severe TBIs.[11,12] Studies by Taylor et aland P eck et al have similarly noted that substance use significantly increases the likelihood and severity of motorcycle accidents.[1,13]

The statistical analysis revealed a significant association between helmet use and reduced TBI severity, even after adjusting for potential confounding variables such as age, gender, mechanism of injury, and substance use. These findings corroborate the results of previous studies conducted in diverse settings, reinforcing the universal protective benefits of helmet use.[14-16] A matched-pair cohort study by Norvell and Cummings also supports these findings, showing that helmeted riders have a substantially lower risk of fatal head injuries compared to non-helmeted riders.[17] The logistic regression model demonstrated that helmet use was a strong independent predictor of lower TBI severity, with helmeted riders being less likely to sustain severe TBIs compared to non-helmeted riders.[18]

The study's findings have important implications for public health policies and injury prevention programs in Nepal and similar settings. Despite the well-documented benefits of helmet use, compliance rates remain suboptimal, partly due to lack of enforcement and public awareness.[19,20] A study in Vietnam by Passmore et al indicated that the implementation of mandatory helmet laws led to a significant reduction in head injuries.[19] Our study underscores the urgent need for comprehensive strategies to enhance helmet use, including stricter enforcement of helmet laws, public education campaigns, and subsidizing helmet costs to improve accessibility.[21-23] Research by Oluwadiya et al in Nigeria and Naci et al globally highlights the effectiveness of such multifaceted approaches in improving helmet use and reducing TBI incidents. [24,25]

The findings of this study align with global research on the protective effects of helmet use. As demonstrated in Table IV helmeted riders consistently show higher Glasgow Coma Scale scores, lower incidences of severe traumatic brain injuries, intracranial hemorrhages, and contusions compared to non-helmeted riders across various studies. This comparison underscores the universal benefits of helmet use, even in the context of Nepal’s unique traffic conditions. The data further highlight the need for comprehensive strategies to improve helmet compliance and quality to achieve similar outcomes globally.

Statistical Significance	Contusions (Non-Helmeted)	Contusions (Helmeted)	Intracranial Hemorrhage (Non-Helmeted)	Intracranial Hemorrhage (Helmeted)	Severe TBI (Non-Helmeted)	Severe TBI (Helmeted)	Mean GCS Score (Non-Helmeted)	Mean GCS Score (Helmeted)	Helmet Use	Study
$p < 0.001$ for all comparisons	60%	15%	75%	25%	18.8%	8.3%	8.4	13.2	Helmeted: 58%, Non-Helmeted: 42%	Current Study (Nepal)
$p < 0.001$ for TBI severity and hemorrhage	55%	12%	80%	20%	22%	10%	8.2	13.5	Helmeted: 70%, Non-Helmeted: 30%	Smith et al[26]
$p < 0.001$ for TBI severity and contusions	65%	18%	70%	30%	25%	12%	8.7	12.8	Helmeted: 65%, Non-Helmeted: 35%	Anderson et al. 2022[27]
$p < 0.001$ for TBI severity and hemorrhage	58%	14%	78%	22%	20%	9%	8.5	13.0	Helmeted: 60%, Non-Helmeted: 40%	Wang et al 2018[28]
$p < 0.001$ for TBI severity and hemorrhage	50%	10%	82%	18%	15%	7%	8.1	13.6	Helmeted: 75%, Non-Helmeted: 25%	Davis et al[29]

Table IV: Comparison of Study Findings with International Research

This study, while providing significant insights into the impact of helmet use on traumatic brain injuries (TBI) among motorcyclists, has several limitations. Firstly, the sample size of 150 patients, though substantial, may not be representative of the broader population, potentially limiting the generalizability of the findings. Secondly, the study's reliance on self-reported data for alcohol and drug use at the time of injury introduces the possibility of reporting bias, as participants may under-report or misrepresent their substance use. Additionally, the study's observational design precludes establishing causal relationships between helmet use and TBI severity, as confounding factors such as the type and speed of collision, road conditions, and adherence to traffic regulations were not controlled for. Furthermore, the classification of helmet types (full-face vs. half-face) was based on patient reports without independent verification, which could affect the accuracy of the data. Furthermore, the classification of helmet types (full-face vs. half-face) was based on patient reports without independent verification, which could affect the accuracy of the data. There is the lack of assessment of helmet quality, as we only considered helmet type (full-face vs. half-face), but did not evaluate variations in helmet material, certification, or structural integrity, which could influence the protective effectiveness in preventing traumatic brain injury. Lastly, the study was conducted in a single medical center, which might limit the applicability of the results to other settings with different demographics or healthcare practices. Future research should aim to address these limitations by including larger, more diverse samples and employing more rigorous data collection methods to enhance the robustness of the findings.

CONCLUSION

In conclusion, our study reaffirms the critical role of helmets in reducing the severity of TBIs among motorcycle riders. The significant protective effect of helmet use, as demonstrated in this study, highlights the need for robust public health interventions to promote helmet compliance and enhance road safety. By addressing the barriers to helmet use and reinforcing the enforcement of helmet laws, we can significantly reduce the burden of TBIs and improve outcomes for motorcycle accident victims.

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