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Predictive Factors Influencing Helmet Usage Among Motorcyclists: A Study at the Largest Trauma Center in Southern Iran

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ABSTRACT

Objectives: This study aimed to identify factors influencing helmet usage behavior among motorcyclists.
Methods: A cross-sectional study of injured motorcyclists was conducted at Shahid Rajaee Hospital (Shiraz, Iran), using the convenience sampling method. Data were collected via a structured medical form, and logistic regression with the "Backward" technique was applied to identify risk factors associated with helmet use.
Results: Among 147 patients, 139 (94.55%) were un-helmeted, and 8 (5.45%) were helmeted. The mean age of helmeted riders was 41.46±17.44 years, compared to 29.21±12.23 years for un-helmeted riders. After data balancing, key predictors of helmet use included riding before noon (OR=10.164, 95% CI [4.543, 22.738]), crashes in urban areas (OR=21.740, 95% CI [5.535, 85.383]), absence of head/neck injuries (OR=4.549, 95% CI [2.075, 9.970]), absence of facial injuries (OR=5.108, 95% CI [1.587, 8.694]).
Conclusion: These findings could assist policymakers in understanding helmet usage behavior and increasing helmet usage rates. They also support evidence-based strategies to reduce traffic crashes. Addressing helmet-related discomfort and enhancing public awareness of helmet benefits could significantly reduce motorcycle-related trauma.

Keywords: Helmet, Motorcycles, Accidents, Traffic.

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Introduction

Road traffic crashes, particularly motorcycle-related incidents, are a leading cause of death and disability worldwide, with over 90% of this burden occurring in low- and middle-income countries (LMICs) [1, 2]. Among these, motorcycle-related crashes contribute significantly to mortality, disability, and economic burdens due to out-of-pocket healthcare expenditures [3]. In Iran, road traffic crashes are a leading cause of injury, particularly among young adults, with motor vehicle crashes being the primary cause of maxillofacial fractures in this population [4].

Despite the proven efficacy of helmets in injury prevention, studies indicated that non-compliant riders face a threefold greater injury risk than helmet users [5]. The World Health Organization (WHO) Decade of Action for Road Safety (2021-2030) aims to reduce road traffic deaths and injuries by 50% by 2030, emphasizing the importance of evidence-based interventions such as helmet use and public awareness campaigns as key strategies [6]. While various factors such as risky driving behaviors and weak traffic law enforcement contribute to crashes, helmet use remains critical for reducing injury severity and mortality [7, 8]. Evidence consistently demonstrated that helmet use significantly lowered the risk of head injuries, fatalities, and hospitalizations following motorcycle crashes [9].

In Iran, despite rising death and disability-adjusted life year (DALY) rates, targeted interventions and increased public awareness could mitigate a substantial proportion of traffic-related injuries [10]. Given Iran's high crash rates, this study focused on Shiraz, a major city where Shahid Rajaee Hospital serves as the primary trauma center, to identify factors influencing helmet use among injured motorcyclists.

Materials and Methods

This cross-sectional study was conducted in 2023, at Shahid Rajaee Hospital, a level-one trauma center in Shiraz, Iran. The study population included motorcyclists admitted to the emergency department within 24 hours post-crash. Due to the acute nature of trauma cases, a convenience sampling method was used to enroll participants. Verbal consent was obtained from either patients or their companions, as approved by our emergency protocol. The study received approval from the Institutional Review Board and Research Ethics Committee of Shiraz University of Medical Sciences (code: IR.SUMS.MED.REC.1398.621).

The required data were collected using a structured medical form comprising two main sections. The first section recorded socio-demographic characteristics, including age, weight, level of education, marital status, and occupational status.

Table 1. Distribution of valid and missing variables of the Injured Patients.

Frequency valid value of prehospital factor		Valid (%)	Missing (%)	Frequency of hospital factor		Valid (%)	Missing (%)
Age		143 (97.3%)	4 (2.7%)	Triage level	1	5 (3.4%)	11 (7.5%)
Wight		140 (95.3%)	7 (4.7%)		2	19 (12.9%)	
Marital statues	Single	84 (57.1%)	0		3	101 (68.7%)	
	Married	63 (42.9%)			4	11 (7.5%)	
Level of education	Under diploma	74 (50.3%)	74 (50.3%)	Damage area head & neck	No	96 (65.3%)	0
	Higher Diploma	60 (40.9%)			Yes	51 (34.7%)	
				Damage area face	No	118 (80.3%)	0
					Yes	29 (19.7%)	
Job	Unemployed	12 (8.2%)	12 (8.2%)	Damage area chest	No	130 (88.4%)	0
	Employee	54 (36.73%)			Yes	17 (11.6%)	
	Tradesman	17 (11.56%)		Damage abdomen	No	137 (93.2%)	0
	Other	20 (13.60%)			Yes	10 (6.8%)	
				Damage spine	No	128 (87.1%)	0
Place of event	Street	127 (86.4%)	0 (0%)		Yes	19 (12.9%)	
	Highway	20 (13.6%)		Area extremity	No	52 (35.4%)	0
Time of event	Am	75 (51.0%)	0 (0%)		Yes	95 (64.6%)	
	Pm	0 (0%)		Area External	No	140 (95.2%)	0
When take place	During work	31 (21.1%)	1 (0.7%)		Yes	7 (4.8%)	
	Recreation	1 (0.7%)		During hospitalization time	<24hours	20 (12.6%)	11 (7.5%)
	Routine activity	27 (18.4%)					
Weather	Sunny	142 (96.6%)	0		24-48hours	19 (12.9%)	
	Rainy	5 (3.4%)			More than 48 hours	97 (66.0%)	
Site of traffic	Urban	128 (87.1%)	0	Discharge	With doctor order	99 (67.3%)	43 (29.3%)
	Rural	19 (12.9%)			With satisfaction	5 (3.4%)	
Driving license	No	91 (61.9%)	0	Injury severity score Valid: 146 (99.31%)		8.62±7.39	1 (0.69%)
	Yes	56 (38.1%)		Glasgow coma scale		145 (98.63%)	2 (1.36%)
Having Private vehicle	No	35 (23.8%)	79 (53.7%)	Systolic blood pressure		139 (94.55%)	8 (5.44%)
	Yes	33 (22.4%)		Diastolic blood pressure		140 (95.23%)	7 (4.77%)
Status location	City	57 (38.8%)	77 (52.4%)	Pulse rate		139 (94.55%)	8 (5.44%)
	Village	13 (8.8%)		Respiratory rate		136 (92.51%)	11(7.49%)
Having passenger	None	106 (72.1%)	0				
	Have passenger	41 (27.89%)					

The second section documented the crash circumstances (time and location of the event) riding conditions, weather conditions, traffic site characteristics, driving license status, vehicle ownership details, location details, and passenger presence. The attending physicians systematically recorded clinical data including triage level, injury sites, hospitalization details, discharge status, vital signs (pulse rate, respiratory rate, blood pressure), and Glasgow Coma Scale (GCS) scores (Table 1).

Descriptive statistics were used to summarize the dataset characteristics. Variables with more than 20% missing values were excluded from the analysis. To address the class imbalance, the Synthetic Minority Over-sampling Technique (SMOTE) was implemented with a K-nearest neighbors (KNN) classifier (k=5). The SMOTE algorithm generated synthetic minority class samples through interpolation between existing instances, while KNN predicted class labels based on nearest neighbor voting. All preprocessing was conducted in Python. Then, the new balanced dataset was imported into SPSS software (version 26). Categorical variables were compared using the Chi-square or the Fisher exact tests as appropriate, and continuous variables were analyzed using independent t-test or Mann-Whitney U tests for non-normally distributed data. Statistical significance was set at $p<0.05$. Backward logistic regression was employed to identify helmet use predictors, reporting adjusted odds ratios (OR) with 95% confidence intervals (CI).

Results

The study included 147 motorcyclists, comprising 139 (94.55%) non-helmeted riders and 8 (5.45%) helmeted riders. The mean age of helmeted riders was 41.46±17.44 years, compared to non-helmeted riders (29.21±12.23 years). Table 1 presents the distribution of valid and missing values for all variables. Following data balancing using the SMOTE technique, the analysis included complete information for 278 individuals (Table 1).

Univariate analysis showed that all examined variables significantly predicted helmet use ($p<0.05$) except for vehicle ownership ($p=0.393$), as detailed in Table 2.

The analysis demonstrated significant associations between helmet use and multiple clinical variables. Injuries to the face, head and neck, chest, abdomen, spine, and extremities, along with external injuries, duration of hospitalization, GCS scores, and respiratory rates all showed statistically significant relationships with helmet use ($p<0.05$), as detailed in Table 3.

Logistic regression analysis using the backward method identified several significant predictors of helmet use. Regarding prehospital factors, married status was associated with significantly reduced odds of helmet use (OR=0.048, 95%CI [0.020-0.115], $p<0.001$), while riding before noon showed 10.16 times greater odds of helmet use compared to afternoon riding (OR=10.16, 95%CI [4.543-22.738], $p<0.001$).

Table 2. Relationship between the pre-hospital variables and us vs. not using helmet in patients.

Prehospital factor		Not use helmet (N=139)	Use helmet (N=8)	*P* value
Age (mean±SD)		29.21±12.23	41.46±17.44	<0.001
Wight (mean±SD)		71.79±17.44	73.54±11.80	0.012
Marital status Frequency (%)	Single	82 (59.0%)	28 (20.1%)	<0.001
	Married	57 (41.0%)	111 (79.9%)	
Job	Unemployed	44 (31.7%)	93 (66.9%)	<0.001
	Employee	56 (40.3%)	29 (20.9%)	
	Tradesman	18 (12.9%)	17 (12.2%)	
	Other	21 (15.1%)	0 (%)	
Place of event	Street	119 (85.6%)	139 (100%)	0.001
	Highway	20 (12.2%)	0 (0%)	
Time of event	A.M	68 (48.9%)	122 (87.8%)	<0.001
	P.M	71 (51.1%)	17 (12.2%)	
When take place	During work	30 (21.6%)	18 (12.9%)	<0.001
	Recreation	28 (20.1%)	0 (%)	
	Routine activity	81 (58.3%)	121 (87.1%)	
Site of traffic crash	Urban	120 (86.3%)	139 (100%)	<0.001
	Rural	19 (13.7%)	0 (0%)	
Weather	Sunny	135 (97.1%)	123 (88.5%)	0.005
	Rainy	4 (2.9%)	16 (11.5%)	
Driving license	No	88 (63.3%)	49 (35.3%)	<0.001
	Yes	51 (36.7%)	90 (64.7%)	
Private vehicle	No	104 (74.8%)	101 (72.7%)	0.393
	Yes	35 (25.2%)	38 (27.3%)	
Number of passengers	Non	102 (73.4%)	62 (44.6%)	<0.001
	Have passenger	37 (26.6%)	77 (55.4%)	

Table 3. Relationship between the hospital variables and us vs. not using helmet in patients.

Hospital factor		**Not use helmet Frequency (N=139)**	**Use helmet Frequency (N=8)**	***P* value**
Triage level, N (%)	1	5 (3.6%)	0 (0%)	0.043
	2	20 (14.4%)	18 (12.9%)	
	3	104 (74.8%)	102 (73.4%)	
	4	10 (7.2%)	19 (13.7%)	
Damage area head & neck, N (%)	No	80 (57.6%)	106 (76.3%)	0.001
	Yes	59 (42.4%)	33 (23.7%)	
Damage area face, N (%)	No	81 (54.0%)	115 (92.74%)	0.001
	Yes	69 (46.0%)	9 (7.26%)	
Damage area chest, N (%)	No	122 (87.0%)	139 (100%)	0.001
	Yes	17 (12.2%)	0	
Damage abdomen, N (%)	No	129 (92.8%)	139 (100%)	0.001
	Yes	10 (7.2%)	0	
Damage spine, N (%)	No	122 (87.8%)	96 (69.1%)	<0.001
	Yes	17(12.2%)	43 (30.9%)	
Area extremity, N (%)	No	50 (36.0%)	34 (24.5%)	0.025
	Yes	89 (64.0%)	105 (75.5%)	
Area external, N (%)	No	132 (95.0%)	139 (100%)	0.007
	Yes	7 (5.0%)	0	
Duration of hospitalization, N (%)	<24hours	21 (15.0%)	18 (12.9%)	0.002
	24-48hours	26 (18.7%)	0 (0%)	
	More than 48 hours	92 (66.2%)	121 (87.1%)	
Discharge, N (%)	With doctor order	133 (95.7%)	121 (87.1%)	0.160
	With satisfaction	1 (0.7%)	18 (12.9%)	
Glasgow coma scale (mean±SD)		14.26±2.34	14.87±0.33	0.003
Systolic blood pressure (mean±SD)		120.07±16.25	119.57±22.03	0.828
Diastolic blood pressure (mean±SD)		71.71±12.65	67.31±12.12	0.674
Pulse rate (mean±SD)		84.29±14.14	82.88±7.51	0.300
Respiratory rate		19.56±2.55	15.80±3.29	<0.001

Table 4. Logistic Regression Coefficients and Odds Ratios for Predictors using vs. not using among motorcycle patients.

Variables (mean±SD)		**B**	**I value**	**OR**	**95% C.I for OR**	
					Upper	**Lower**
Prehospital						
Marital status	Single	-3.035	<0.001	0.048	0.020	0.115
	Married	Ref.	Ref.	Ref.	Ref.	Ref.
Time of event	A.M	2.319	<0.001	10.164	4.543	22.738
	P.M	Ref.	Ref.	Ref.	Ref.	Ref.
Weather conditions on the event	Sunny	-2.820	<0.001	0.060	0.016	0.224
	Rainy and snowy	Ref.	Ref.	Ref.	Ref.	Ref.
Site of traffic crash	Urban	3.079	<0.001	21.740	5.535	85.383
	Rural	Ref.	Ref.	Ref.	Ref.	Ref.
Driving license	No	-1.897	<0.001	0.150	0.069	0.327
	Yes	Ref.	Ref.	Ref.	Ref.	Ref.
Hospital						
Glasgow coma scale		0.761	<0.001	2.140	1.790	2.559
Respiratory rate		-0.566	<0.001	0.568	0.497	0.649
Damaged area head & neck	No	1.515	<0.001	4.549	2.075	9.970
	Yes	Ref.	Ref.	Ref.	Ref.	Ref.
Damage area face	No	1.630	<0.001	5.108	1.587	8.694
	Yes	Ref.	Ref.	Ref.	Ref.	Ref.
Damaged area spine	No	-2.927	<0.001	0.054	0.021	0.138
	Yes	Ref.	Ref.	Ref.	Ref.	Ref.

Riders in sunny weather conditions had significantly reduced odds of helmet use compared to rainy or snowy conditions (OR=0.060, 95% CI [0.016-0.224], $p<0.001$). Urban crash locations were associated with 21.740 times greater odds of helmet use compared to rural locations (OR=21.740, 95% CI [5.535-85.383], $p<0.001$). Besides, patients without a driving license showed significantly reduced helmet use (OR=0.150, 95% CI [0.069-0.327], $p<0.001$).

For in-hospital factors, each unit increase in GCS score was associated with 2.140 times greater odds of helmet use (OR=2.140, 95% CI [1.790- 2.559], $p<0.001$). Higher respiratory rates showed a significant association with helmet use (OR=0.568, 95%CI [0.497-0.649], $p<0.001$).

Protective effects were particularly notable for head and neck injuries, with helmeted riders showing 4.549 times greater odds of avoiding such injuries (OR=4.549,95%CI [2.075-9.970], $p<0.001$), and 5.11 times greater odds of avoiding facial injuries (OR=5.108, 95% CI [1.587-8.694], $p<0.001$). The odds of not being damaged in a spinal area in those who use a helmet was 5.4% less than those who did not use it (OR=0.054, 95% CI [0.021-0.138], $p<0.001$). Complete regression results are presented in Table 4.

Discussion

While motorcycles serve as a crucial transportation alternative in many developing countries, they represent the most hazardous form of motorized transport [11]. This safety concern has made risk reduction a priority for transportation planners, public health authorities, and policymakers [12]. The present study identified several key predictive factors influencing helmet use among motorcyclists in Shiraz, Iran. Before data balancing, the observed helmet usage rate was significantly low (5.4%). This finding contrasted sharply with WHO estimates of Iran's overall helmet usage rate (35%), which predominantly reflected compliance in major urban centers [13]. Notably, Shiraz—despite its status as a major metropolitan area—demonstrated significantly lower adoption rates than these national scales. This substantial discrepancy between regional and national prevalence estimates underscored the importance of localized, context-specific interventions to improve helmet compliance, rather than relying solely on country-wide averages for policy planning.

Regional disparities in helmet use were evident when comparing the findings of the present study with other Iranian studies. Amirjamshidi *et al.,* reported a 75% helmet use rate in Tehran, while Zamani *et al.,* documented only 10% in Ahwaz [14, 15]. International comparisons revealed even greater variation, with Tosi *et al.,* reporting 81.3% helmet compliance in Argentina [16]. These substantial differences likely reflected variations in cultural norms, enforcement of helmet legislation, and socioeconomic factors across regions [17].

Our findings revealed significant age-related differences in helmet use behavior, with helmeted riders being substantially older (mean age=41.46±17.44 years) than non-helmeted riders (mean age=29.21±12.23 years). This age disparity suggested that middle-aged individuals demonstrated greater compliance with safety regulations, a pattern potentially explained by their increased sense of responsibility [18]. The occupational data further illuminated this phenomenon, showing that non-helmeted riders were predominantly employed individuals potentially using motorcycles for daily commuting, whereas helmet users tended to be unemployed. This occupational pattern raises significant public health concerns, as injuries among working-age populations can result in substantial productivity losses across various economic sectors, potentially causing considerable economic damage and disrupting essential community services. These findings were consistent with a study by Yadollahi *et al.,* [19]. Marital status was another significant factor influencing helmet use, with married riders demonstrating higher compliance rates than their unmarried counterparts. This finding was consistent with existing literature suggesting that married individuals generally engaged in fewer risky behaviors, likely due to higher levels of familial responsibilities than unmarried riders [20]. Furthermore, several studies documented that married individuals experienced fewer severe injuries in road traffic accidents [21, 22], supporting the notion that family obligations might promote safer riding practices.

Similarly, the study found a significant positive association between the ownership of a motorcycle license and helmet use, with licensed riders demonstrating substantially higher helmet compliance rates than unlicensed riders. This finding contrasted with the results reported by Niamako Aidoo *et al.,* [12], suggesting potential variations in licensing enforcement or cultural factors across different study populations.

Weather conditions and time of the day emerged as other important factors for helmet-wearing behavior. Many studies showed that there were differences in helmet usage patterns across different times and locations. They used helmets rarely at night and physical discomfort and absence of police surveillance were the most common reasons for not wearing helmets, which was aligned with our findings [22, 23].

Mokhtari *et al.,* demonstrated significant seasonal and weekly variations in helmet use among Kerman motorcyclists, with lower compliance rates observed during summer months (vs. winter) and weekends (vs. weekdays) [24].

On the other hand, the logistic regression analysis of hospital factors identified facial, cervical, and spinal injuries along with GCS scores as significant clinical predictors of helmet use. In this regard, in a study by Baru *et al.,* crashes involving motorcyclists or motorcycle passengers without a helmet increased the risk of injury by more than four times [25], which further substantiated the well-documented protective effect of helmets against severe trauma [26]. A recent Cochrane review of 61 observational studies estimated that helmet use reduced the odds of mortality and head injury by 42% and 69 %, respectively [27]. A multi-state study in the U.S.A. (n=73,759) demonstrated the effectiveness of universal helmet laws, with riders in partial-law states experiencing significantly higher rates of head/facial injuries and traumatic brain injuries[9]. Regarding cervical spine injuries, current evidence remains contradictory. Paul *et al.,* found a statistically significant lower likelihood of suffering a CSI and vertebral fractures and ligamentous injuries among helmeted motorcyclists, suggesting potential protective benefits without increased fracture risk [28]. Conversely, a systematic review by Koohi and Soori concluded that the use of a safety helmet failed to reduce the risk of injury to the neck and cervical spine compared to non-helmeted riders [29]. This discrepancy might be related to the helmet's biomechanical effects during impact, which further increases the contraction and expansion of the neck and increases the risk of neck injury [30]. While various helmet types demonstrate differing effectiveness in preventing facial and cervical injuries, there is insufficient evidence for definitive comparisons. The present study also investigated the safety of motorcyclists and speed control during the crash. It was found that wearing a helmet decreased the severity of trauma, which was consistent with Spencer *et al.'s* findings [31]. In addition, Galanis *et al.,* mentioned that helmet use could sufficiently mitigate trauma severity to prevent the need for medical intervention in some cases [32].

While this study identified key factors influencing helmet utilization patterns, several important dimensions were beyond its scope. First, the research did not evaluate helmet quality standards or technical specifications, including variations in construction materials, safety certifications, or design features. Second, the present study failed to account for motorcycle types, biomechanics of trauma, impact of velocities during a crash, or helmet-related sensory effects (visual/auditory limitations). Third, the findings could not be generalized to specialized riding contexts (e.g., racing circuits, motocross). Fourth, the study did not examine enforcement practices or socioeconomic determinants of helmet compliance. Future studies should systematically investigate both helmet standards and compliance interventions. For a more comprehensive analysis, subsequent research ought to incorporate the examination of various helmet types and brands, specifically targeting the factors associated with helmet non-use.

This study, conducted at a Level 1 trauma center, identified key factors influencing helmet use among motorcyclists. The findings confirmed that helmet use was significantly associated with reduced mortality and injury risk in traffic crashes. Motorcycle crashes are a major, yet often overlooked, public health challenge requiring sustained prevention efforts. Helmets represent one of the most effective safety devices for motorcyclists, particularly crucial as in many cases, motorcyclists are the breadwinners of the family, and they are at their productive age, and motorcycle safety devices become of greater importance. Furthermore, motorcyclist training programs and initiatives to change attitudes and behaviors should be implemented to increase helmet use and decrease risky behaviors during riding. This study identified key predictors of helmet use among motorcyclists in Shiraz, Iran, demonstrating that helmet use significantly reduces injury severity. Accordingly, policymakers should prioritize strict enforcement of helmet laws public awareness campaigns, and integration of safety education into licensing procedures.

Declaration

Ethical Approval and Consent to Participate: Ethical approval was obtained from the Institutional Review Board and Research Ethics Committee of Shiraz University of Medical Sciences (code: IR.SUMS.MED.REC.1398.621).

Consent for Publication: All authors expressed their consent to the publication of this study.

Conflict of Interest: The authors declared that there was no conflict of interest.

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Author's Contribution: MY: Designed the study and did the literature search, data acquisition, and analysis; FF: Data acquisition; SBP: Data acquisition; MZ: Analyzed data and wrote the first draft of the manuscript. All authors contributed to the interpretation of the data and writing of the manuscript and approved the final version of the manuscript.

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