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Evaluation of the severity and pattern of motorcycle-related injuries among riders and passengers in Iran: a retrospective study

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Abstract: **Objective:** Motorcycle-related traffic crashes remain a significant cause of severe injuries and fatalities, particularly in young populations. This study aimed to compare the injury severity and patterns sustained by motorcycle riders and passengers in crashes.

Methods: A retrospective analysis was conducted on motorcycle crash victims, including both riders and passengers, evaluated at the forensic medical organization in Iran from 2020 to 2022. Variables such as injury type, helmet use, and demographic factors were compared. The chi-squared test was applied to categorical variables, with P-values of <0.05 considered significant. The injury severity score (ISS) and the abbreviated injury scale (AIS) were used to assess trauma severity.

Results: Of 214 cases (81.8% male), helmet use was significantly higher among riders than passengers (39.6% vs. 14.8%, P<0.05). Passengers demonstrated a greater risk of severe injury (45.4%) than riders (27.4%, P=0.01). Head injuries were significantly more prevalent among passengers (13%) than riders (5.7%, P=0.019), correlating with lower helmet use among the passengers. Additionally, fractures and dislocations were more common in passengers, while external injuries predominated in riders.

Conclusion: Strengthening helmet regulations for passengers is critical to reducing head trauma. Stricter enforcement of traffic safety measures could significantly mitigate fatalities, especially among novice riders.

Keywords: Accident; Motorcycle; Passengers; Riders ; Trauma

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1. Introduction

The road traffic accidents are defined as the world's third leading cause of death. Deaths and injuries as a result of road traffic crashes are considered a major drain on the country's resources (1).

Motorcycles are a common mode of transport in low- and middle-income countries.. In Iran traffic crashes are among the top three causes of deaths. It has the highest number of road accidents compared with other countries (2) Iran accounts for over 85% of fatalities and 90% of disabilities due to road traffic crashes within the region. Any kind of crashes increased the burden of expenses to both society and the individuals involved (3,4). Economic losses of all motor-vehicle crashes (fatal, nonfatal injury, and property damage) are now reaching $250 billion in the United States annually, along with motorcycle riders and their passengers, who have a higher percentage of fatal injury among all motor vehicle users. However, Insurance companies reimburse only 25% of the expenses incurred by a traffic accident (5). Most road traffic deaths and injuries can be regarded as predictable, preventable events and not randomly occurring accidents. Despite the rise in popularity and new vehicle registrations in high-income countries, the number of traffic-related deaths has remained the same for ages, accompanying the implementation of behavior-based interventions on one hand and the evidence base on the other hand (6,7).

The interventions, including integrating safety measures into the road design, designing protective vehicles, enforcing credible speed limits, setting and enforcing the use of seat belts and helmets, and preventing deadly drowsy driving, contribute effectively to reducing accidents, injuries and deaths (5-8). Disregarding the nature and mechanisms of accidents, road traffic injuries cause a significant reduction in disability adjusted life years (DALYs), impose a considerable burden on society, and additionally lead to a lower quality of life for road injury survivors (9,10). A cross-sectional retrospective study by King et al. in New Zealand (2019) determined that patients who were hospitalized and sustained head injuries (traumatic brain injury in particular) resulting

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from traffic accidents were more likely involved in a motorcycle–vehicle crash (11).

A descriptive study conducted by Singh et al. (2014) in India evaluated the incidence and the pattern of injuries. The prevalence of associated injuries with traffic crashes was as follows: chest injury, 2.4%, abdominal trauma, 1.6%, traumatic spinal cord injury 1.4%. The most common location of skull fractures was frontal (47.5 %), followed by parietal (20.4 %) (12).

In another study focused on facial trauma in motorcyclists (2019), Kazemian et al. reported that for helmeted motorcyclists involved in a traffic accident (6.25 %), there was a protective association with a significant reduction in the occurrence and severity of facial fracture (13). A comparison of injury severity and different seating positions is considered an effective factor in the development of a comprehensive approach to traffic injury prevention. Moreover, the evaluation of injury patterns' varieties according to the rider's seat position (rider and passengers) reduces the severity of accidents (14,15). In some cases, a physical examination is required based on a judgment precedent to detect rider identification. Instances of riders switching places with passengers to evade law enforcement highlight the importance of accurate identity recognition in preventing fraud. In the event of a road traffic collision, particularly in cases reported by the police where physical evidence has been tampered with or the collision has resulted in a death, the identification and recognition of riders is crucial for the police in their investigation of the accident scene.

While motorcycle accidents are widely studied, specific gaps remain in understanding the differences in injury patterns and severity between riders and passengers in Iran. The findings align with the national trends reported by Zargar et al., who identified high rates of head injuries among motorcycle occupants. However, our study advances this understanding by delineating injury patterns based on seating position and helmet use. Notably, while Zargar reported a 9% helmet usage rate, while there are a significant impact of stricter enforcement policies in recent years (1). Nevertheless, the persistently low helmet use among passengers (14.8%) and their disproportionately high risk of severe head injuries (13%) highlight a critical gap in current regulations. Furthermore, unlike Navabi et al., who focused on pediatric populations, this study provides a broader demographic scope, including adults, thereby offering a comprehensive perspective on injury trends across all age groups in Iran (2). This study aims to address this gap by assessing and comparing these differences to better inform targeted safety regulations. Given the high incidence of passenger-related injuries and the generally lower rates of helmet use among passengers, we hypothesize that passengers are more susceptible to severe injuries than riders. Additionally, a focus on injury patterns relative to helmet use and seating position may highlight critical areas for intervention.

Identifying the rider's role and position during the crash is critical for determining responsibility and enhancing accident investigations. If there were subtle differences in the pattern of injury between the rider and the passengers. This study aimed to evaluate the severity and pattern of injuries between motorcyclists and their passengers in crashes.

2. Methods

2.1. Study design

This retrospective cross-sectional study analyzed medical records of motorcycle accident victims, including both riders and pillion passengers, referred to forensic medical units in Iran from 2020 to 2022. The study assessed differences in injury severity and patterns based on seating position and helmet use. Data collection was based on a comprehensive review of medical records, focusing on demographics, injury characteristics, and clinical findings.

2.2. Ethical considerations

This study complied with ethical standards and received formal approval from the Tehran University of Medical Sciences Ethics Committee (approval code: IR.TUMS.MEDICINE.REC.1399.259). All participants or their legal representatives provided informed consent before inclusion in the study. Confidentiality was rigorously maintained by de-identifying all participant data, and only authorized personnel accessed the records. Throughout the research, participant welfare was prioritized by adhering to ethical guidelines that ensured minimal risk exposure, safeguarding their rights and privacy during data collection and analysis.

2.3. Data gathering

Data were obtained from the medical records of accident cases evaluated in forensic medical examination centers. Eligible cases included individuals admitted to hospitals for injury evaluation or forensic examination due to motorcycle-related crashes. Cases were excluded if they involved suspected staged crashes or incomplete records. Conscious participants provided informed consent, while consent for unconscious patients was secured through legal guardians or family members as per ethical guidelines. Variables extracted included demographic information (age, gender, helmet use), accident details (type of collision, time, and place), injury types, and severity indicators. Incomplete records were defined as missing critical data such as demographic details, injury descriptions, accident characteristics, or helmet use status. Records that lacked verification from the forensic medical organization or had inconsistencies in reported variables were excluded to minimize bias and ensure robust data quality. Suspected staged crashes were excluded based on criteria including conflicting eyewitness accounts, absence of corroborative physical evidence (e.g., skid marks, vehicle damage), or discrepancies between medical findings and reported accident mechanisms. Additionally, cases

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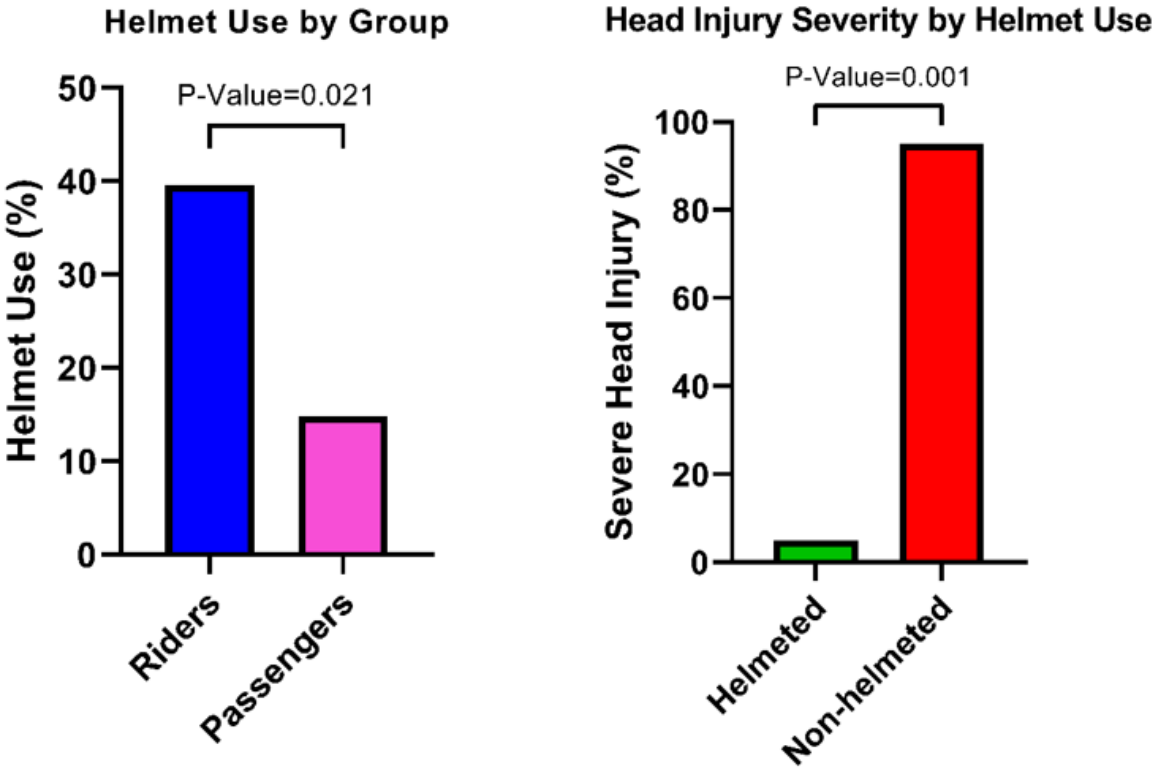


Figure 1 Comparison of helmet use and head injury severity in riders and passengers. This figure illustrates two aspects of motorcycle accident data: helmet use among riders and passengers, and the severity of head injuries between helmeted and non-helmeted individuals. The left panel shows that helmet use was significantly higher among riders (39.6%) compared to passengers (14.8%) (P=0.021). The right panel compares the proportion of severe head injuries among helmeted (5%) and non-helmeted (95%) participants, highlighting a strong association between helmet use and reduced injury severity (P=0.001)

Table 1 Demographic characteristics

Characteristic	Riders (n=106)	Passengers (n=108)	P-value
Gender (male/female)	100/6	75/33	0.032
Median age (years)	28	31	0.654
Age range (years)	16–75	3–73	0.654
Prior accident experience	80%	80%	1
Alcohol impairment	6.60%	0%	0.048
Helmet use	39.60%	14.80%	0.021

Table 2 Injury patterns by anatomical region

Anatomical region	Riders (%)	Passengers (%)	P-value
Head & neck	13.2	15.7	0.151
Trunk	3.8	4.6	0.45
Upper extremities	6.6	0.9	0.042
Lower extremities	9.4	13	0.233
External injuries (skin)	44.3	28.7	0.041
Fractures & dislocations	7.5	18.5	0.033
Head injuries	5.7	13	0.028

flagged by law enforcement or forensic experts as suspicious were independently reviewed and excluded if deemed inconsistent with typical crash patterns.

Injury severity was quantified using the injury severity score (ISS) and the abbreviated injury scale (AIS), both of which are well-established systems in trauma assessment. The AIS classifies injuries across six anatomical regions (1-head and neck, 2-face, 3-chest, 4-abdomen, 5-extremities, and 6-

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Table 3 Injury severity comparisons

Injury severity	Riders (%)	Passengers (%)	P-value
Severe	27.4	45.4	0.01
Moderate	20.8	21.3	0.923
Mild	40.6	26.9	0.046
Mortality	25	38.6	0.028

Table 4 Accident timing and duration

Accident characteristics	Frequency (%)	Common time frame	P-value
Peak accident times	79.4	6 PM to 5 AM	0.012
Duration from start of ride	79.4	<30 minutes	0.032
Seasonal distribution	33.6 (Summer)	Summer > Spring	0.049

external). Injuries are graded on a scale from 1 (minor) to 6 (unsurvivable), facilitating targeted triage and treatment planning.

The ISS, derived from the AIS scores, calculates trauma severity by summing the squares of the three highest AIS scores across different body regions. Scores range from 0 to 75, with higher scores indicating greater severity. For this study, an ISS score of 1–8 was classified as minor, 9–15 as moderate, and greater than 15 as major traumas. A significant focus was placed on understanding the distribution of ISS scores across riders and passengers, examining how helmet use and seating position influenced severity.

2.4. Statistical analysis

All analyses were conducted using SPSS 27.0, with statistical significance set at a P-value of <0.05. We employed the Kolmogorov-Smirnov test to assess the normality of continuous variables. For normally distributed data, a t-test was used to compare means between groups. However, due to non-normal distribution in some variables, non-parametric tests (Mann-Whitney U test) were used to compare these variables. Specifically, non-parametric tests were applied where the distribution could not be normalized, providing a robust method for analyzing differences without relying on parametric assumptions.

Significance levels were interpreted as follows: P-values <0.05 were deemed statistically significant, highlighting differences between the groups, while higher P-values indicated no statistically significant differences. Both parametric and non-parametric tests ensured an accurate assessment of differences across diverse data types, especially in cases with small sample sizes or skewed data distributions.

3. Results

3.1. Demographic characteristics

Out of the 214 participants in this study, 175 (81.8%) were males and 39 (18.2%) were females. All female participants were passengers, which contributed to a significant gender difference between the groups (P<0.05). The ages of riders ranged from 16 to 75 years, with a median age of 28 years, while passengers ranged from 3 to 73 years, with a median age of 31 years. No significant age differences were observed between the two groups (P=0.654). The body mass index (BMI) also did not significantly differ between riders and passengers (P=0.694). Furthermore, most participants (80%) reported no prior accident experience, and only a small percentage of riders (6.6%) were found to have been alcohol-impaired at the time of the accident. These demographic characteristics are summarized in table 1, which shows the distribution of key demographic factors across riders and passengers.

3.2. Injury patterns

The injury patterns varied significantly between riders and passengers, highlighting the different risk factors each group faces. Passengers were notably more likely to experience fractures and dislocations (18.5%) compared to riders (7.5%, P= 0.019), while riders had a higher incidence of external injuries such as abrasions, lacerations and soft tissue damage (44.3% vs. 28.7%). Additionally, head injuries were observed more frequently in passengers than riders (13% vs. 5.7%, P=0.019), a finding that likely correlates with lower helmet use among passengers. Injuries were further categorized anatomically, revealing that passengers were more susceptible to upper limb injuries while riders predominantly suffered from lower limb injuries, although these differences were not statistically significant (P=0.151). A detailed breakdown of the types of injuries by anatomical region is presented in table 2.

3.3. Helmet use and its association with injury severity

Helmet use was significantly more prevalent among riders than passengers (39.6% vs. 14.8%, P<0.05). The data demonstrated a strong association between helmet use and reduced severity of head injuries; helmeted individuals had a notably lower incidence of moderate to severe head injuries compared to non-helmeted participants (5% vs. 95%, P<0.001). This finding underscores the critical protective role of helmets in preventing severe head injuries, particularly for pas-

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sengers, who are less likely to wear helmets. For visual clarity, a bar chart illustrating helmet usage and corresponding rates of head injury severity among riders and passengers is recommended. Figure1 can provide a comparative view of helmet use and head injury severity by seating position.

3.4. Statistical comparisons between drivers and passengers

The comparison of injury severity revealed that passengers were at a considerably higher risk of sustaining severe injuries than riders (45.4% vs. 27.4%, P=0.01). Passengers were also more likely to undergo surgical interventions following the accident (P=0.002), and they experienced a higher mortality rate than riders (38.6% vs. 25%, P=0.028). Mortality analysis showed that more than 41% of all fatalities occurred within 24 hours of the accident, followed by fatalities occurring between 7–14 days (34.3%). Traumatic head injuries were identified as the primary cause of death among passengers (60%), in contrast to riders, where the primary causes were often multiple injuries involving various body regions (65.2% vs. 35%).

3.5. Accident characteristics and environmental factors

Seasonal and temporal factors also played a role in the distribution of accidents. The highest incidence of motorcycle crashes (33.6%) occurred during the summer, followed by spring, and a large proportion of accidents (79.4%) occurred within 30 minutes of the start of the journey. Additionally, nighttime hours (6 PM to 5 AM) accounted for most accidents, likely due to reduced visibility and increased fatigue among drivers. Table 3 displays the distribution of accidents by time of day and duration from the start of the journey.

4. Discussion

This study with a comparative-descriptive approach attempted to evaluate the severity and pattern of injuries between the involved motorcyclists and the pillion passengers in traffic crashes that were referred to the forensic medical organization. Demographic details, mode of injury, as well as clinical findings were studied, focusing on particular interviews, examination results, paraclinical procedures, along with analyzing accurate data on patients' profiles. Most accidents occurred during nighttime hours (6 PM to 5 AM), consistent with previous research attributing such trends to reduced visibility, driver fatigue, and inadequate street lighting. Implementing targeted interventions, such as enhanced road illumination and awareness campaigns on nighttime driving risks, could reduce these incidents (3,4).

The median age of riders and passengers who participated in this study was 28 and 31 years, respectively, with no statistically significant difference between the mean ages. Several studies have been conducted worldwide in the same manner, with the Sakumar's study on riders and passengers in India, which included riders aged 21 to 30 years old, with most passengers aged over 50 (16). The passengers' ages in Shroti's study also corresponded with the results of Sakumar's study (17).

The Majority of motorcyclists involved in Zargar's study were younger than 30 years old (1). Women aged 40 years and over constituted a greater number of passengers in Julius's survey (18). It was noted that younger generations comprise the greatest share of motorcyclists. The growth of motorcycle registration among the youths resulting from the abundance of traffic congestion, the cost-effectiveness of motorcycles, and the launch of a new business, such as a dispatch rider business, is almost doubling every year. The study sample included more than 70 percent of riders licensed to operate the motorcycles, which represented higher involvement of valid license holders by comparison with the licensed proportion of 22 percent participated in Yedalhi et al. investigation, additionally the zero percentage of motorcyclists with a valid license covered by Nazzago's report (19,20) The results provided convincing evidence that strictly monitoring has resulted in significant declines in unlicensed and uninsured driving, as included in our study, when compared to the research conducted by Yedalhi et al. Over half of the riders participated in a recent study (57.5%), and held a license for 12 months prior. Our findings indicate that alcohol impairment was a contributing factor in 6.6% of motorcycle crashes involving riders. This aligns with studies highlighting the role of alcohol in delayed reaction times and impaired judgment, which significantly increase crash risk. Strengthening roadside alcohol testing and enforcement measures could mitigate this issue (5).

The following findings support the idea that a lack of experience and driving skills can contribute to the high incidence of road traffic accidents, particularly among motorcyclists. Furthermore, 17.2 % of riders were identified with previous driving convictions. A higher rate of riders with a history of impaired driving on their records joined the research conducted by Mahnaz Yedalhi and her colleagues (28.5%). Given the low incidence of protective equipment use by not properly licensed motorcyclists observed in Yedalhi's study, in contrast with higher rates of license holders in our study, it seems that less instrumental and normative motives for compliance with the law, along with this difference, underscore the impact of unsafe driving behaviours. Well-conducted analysis of the available data indicated that the highest prevalence of accidents was observed in the summer season (33%), followed by the spring season. These findings concord with previous studies performed by Navabi et al. and Zargar et al.(1,2). Maximum accidents occurred between 6 p.m. and 5 a.m. A high concordance was identified between the current findings and the study results undertaken by Shroty et al. Several previous studies (Julius et al.; Tavakoli et al.) also reported a higher prevalence of accidents during the evening and late night (17,18,21). Regarding distorted perception and reduction in visibility due to darkness or climate changes, inadequate street lighting, as well as driving in a state of

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fatigue or drowsiness, may contribute to the occurrence of driving accidents. Furthermore, most accidents (79%) occurred within less than 30 minutes after the start of the journey. Considering the high proportion of motorcycle use in urban areas covering short-distance trips (less than 30 minutes long), increased accident volumes occurring within that timeframe could be realistically expected.

Likewise, more than 39% of motorcyclists reported using a helmet while riding. Shruthi et al. estimated this group to include approximately 21% of injured riders. The seminal works of Zargar et al, Navabi et al., and Yedali et al showed that 9%, 10%, and 15.5%, respectively, of motorcycle riders had worn helmets at the time of crashes (17,1,19,2). Factors that may have contributed to the higher rate of protective equipment use in our study compared to other conducted research include enhancing societal awareness, continuously monitoring the critical indicators associated with risky driving, and strictly enforcing penalties in recent years.

The statistically significant increases in helmet use among motorcycle riders in this study continued to be higher than the rate of helmet use among the crash-involved passengers (39.6% of riders compared to 14.8% of passengers). The considerable magnitude of helmet wearing behaviour among riders can be attributed to stricter driving regulations with tighter restrictions on riders in our country, similar to the helmet mandate forcing motorcyclists to wear helmets. In contrast, passengers' helmet rule violations remained mostly unregulated. The non-use of safety helmets among pillion passengers with no access to protective equipment, along with non-helmeted travellers of shorter distances, was also observed.

During the study, researchers found that out of the total of 106 motorcycles investigated in current study (two motorcycles carrying more than one passenger), 64 cases (60.3%) were involved in a collision between a motorcycle and a light vehicle which agreed with several previous studies (Nazgo study and Zargar et al. (1,20). A study by Shruthi provides a logical explanation in which motorcycles are the most commonly involved vehicles in traffic crashes due to the higher prevalence of motorcycle use as a mode of transportation in India (17).

Most of the riders and the pillion passengers included in this study sustained multiple injuries, which were defined as patients with two or more severely injured areas of the body using an anatomical base classification. There was no significant statistical difference observed in the anatomical location of injuries between motorcycle riders and their passengers (P=0.151). In the meanwhile, research performed by Yadollahi et al. indicated a higher occurrence of head and neck injuries in passengers; another study conducted by Zao et al. in 2011 revealed that motorcycle riders were at greater risk for head and perineal injuries than passengers (19,22).

There was a significant difference in patterns of injuries sustained by motorcycle riders with those suffered by pillion passengers. External injuries, including abrasions, lacerations, contusions, and soft tissue damage, constituted the most common injuries sustained by riders compared with passengers. However, fractures and dislocations in limbs are considered the most frequent injuries suffered by passengers. This was followed by chest, spinal column, as well as head injuries (skull fractures, facial bone fractures, brain injury, meningeal bleeding, etc.).

The aforementioned results may be derived from the inappropriate utilization of helmets and the passengers' poor hazard perception compared to riders when encountering hazardous situations on the road ahead, which is found to relate to different injury patterns in passengers. As discussed in a study by Mahnaz Yadalhi et al., external injuries to the skin and subcutaneous tissues, including external genital injuries, were significantly more common in motorcycle riders, whereas pillion passengers were diagnosed with more serious head and neck injuries (19).

However, several studies, including Chiang et al. Nuper Proti et al., (2014) reported no statistically significant difference in the characteristics of injuries for both riders and passengers (23,24). The prevalence of head injuries among passengers reflects inadequate helmet use, reduced hazard perception, and insufficient preparedness compared to riders, compounded by seating positions and visibility challenges. A discordance was defined between the current findings and those described in Mahnaz Yadalehi's study in 2019 and Nuperproti's (19,21).

An investigation into traumatic deaths caused by fatal crashes revealed that most fatalities (41%) occurred within the 24 hours after injury, followed by approximately 35 % of the total deaths occurring between less than 7 days post-injury, indicating the severity of the injuries in the deceased patients. In most cases, acute trauma, known as primary injury, is associated with substantial morbidity and mortality, considered the underlying cause of death, whereas secondary injury is recognized as severe complications identified with a lower case fatality rate. To ascertain the cause of death in reported cases, the analysis of the autopsy reports was performed. It emerged that the most common cause of death was head injuries, with a high prevalence in passengers compared to riders (60%) in passengers versus 34.8% in riders, which was in agreement with both Sakomar and Ravikumar's study results (16,25). A concordance was achieved as the passengers' higher rate of head injury (compared to riders) were consistent with their lower rate of helmet use demonstrated the important role of helmets in preventing severe brain injuries.

The findings in this study align with several international reports that emphasize the importance of helmet use in reducing the severity of head injuries among motorcycle occupants. For instance, a study by Chiang et al. (2014) in Taiwan found that riders and passengers had differing patterns of injury, with passengers experiencing more head trauma, likely due to lower helmet usage, similar to our findings in Iran (23). Furthermore, in a study by Sukumar et al. (2018), which ex-

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amined injury severity among pillion riders in India, passengers consistently showed higher head injury rates compared to riders due to significantly lower helmet use rates (16). Unlike some Western countries where strict enforcement has increased helmet usage among all motorcycle occupants, in many low- and middle-income countries, including Iran and India, helmet use remains significantly lower among passengers (17).

5. Limitations

The retrospective design of this study introduces inherent limitations, particularly selection biases arising from the reliance on hospital and forensic medical records. A significant subset of motorcycle-related accidents, especially non-hospitalized cases or those resulting in minor injuries, may remain unreported. This omission could potentially skew the findings, leading to an overrepresentation of severe injuries and fatalities. Moreover, unreported accidents may differ systematically from reported ones in terms of demographic characteristics, helmet use, and injury patterns, introducing further bias.

Additionally, the lack of data on pre-hospital care and accident circumstances limits our ability to control for confounding factors such as variability in emergency response times and road conditions. The absence of a comprehensive national registry for traffic accidents exacerbates this issue. Future studies employing prospective designs with broader population coverage, including non-hospitalized individuals and near-miss events, are essential to provide a more balanced understanding of motorcycle-related injuries.

6. Conclusion

Based on the statistically significant differences observed among the patients (riders and pillion passengers) in terms of injury severity and patterns, hence strict implementation of traffic regulations regarding the mandatory use of helmets among passengers along with other interventions focused on reduction of injuries resulting from motorcycle accidents are necessary. Additionally, novice and newly licensed riders with less than one-year experience of driving, estimated to be more likely to engage in traffic crashes, suggesting more legislative efforts associated with improved driving behavior and a reduced crash risk. Moreover, according to the provided description of fatality cases where helmet use was not recorded for both deceased rider and passenger, it might be possible to differentiate between the injuries sustained by the rider and the passenger based on the injury patterns, which can assist in determining the rider's responsibility. One of the practical objectives of this research was to potentially differentiate between the seat positions of riders and passengers based on observed injury patterns, but we couldn't complete predefined goal judging by the results of this study. However, no significant differences were found in injuries between riders and passengers participated in studies by Nopper et al., Chang, and Salamati et al. (23,24,26). Further studies are needed to investigate the observed differences in the Sakomar and Ravikumar studies (16,25).

This study highlights significant differences in injury patterns and severity between motorcycle riders and passengers, with passengers facing a disproportionately higher risk of severe head injuries due to low helmet use. These findings underscore the urgent need for targeted interventions, such as stricter enforcement of helmet regulations for passengers and enhanced public awareness campaigns on road safety. Policymakers should prioritize the implementation of comprehensive traffic safety programs, including subsidies for affordable helmets, stricter licensing requirements, and public education initiatives to address risk factors identified in this study. Furthermore, the development of infrastructure to support safer riding conditions, such as improved lighting and designated motorcycle lanes, could reduce the incidence and severity of accidents. By aligning these recommendations with national road safety strategies, we can significantly mitigate the burden of motorcycle-related injuries and fatalities in Iran.

7. Declarations

7.1. Acknowledgement

None.

7.2. Authors' contribution

Conceptualization: MA; Data curation: AK, RK; Formal analysis: EB; Investigation: MHS, MA; Methodology: EB; Project administration: MHS, MA; Resources: MHS, MA, RK; Validation: MHS, MA; Visualization: MHS, MA; Writing–original draft: MA, AK, RK, EB, MHS; Writing–review & editing: MHS, MA.

7.3. Conflict of interest

The authors declare no conflict of interest to disclose regarding this manuscript.

7.4. Funding

Not Applicable.

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