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Risk of death from motorcycle accidents in North-western Iran and associated factors

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ABSTRACT

Introduction: Death from motorcycle crashes has destructive effects on the society. This study aims to identity the risk of death from motorcycle crashes in East Azarbaijan Province, Iran. *Method*: This prospective cohort study was conducted based on the data of those injured in motorcycle accidents admitted to Emam Reza and Shohada Hospitals, Tabriz. The death data were obtained from Forensic Medicinal Organization, from May 2018 to December 2019. *Results*: Among 2008 injured people, 284 (14.1%) died during the study. Based on the multivariable model, the risk of death in the people aged above 65 was 2.02 times (95% CI: 1.08-3.77) higher than other ages. Crashes occurring outside the cities were 2.10 times (95% CI: 1.35-3.18) riskier than those happening inside the cities. Crashes at the dawn and when the motorcycle hit a fixed object increased the risk of death by 5.12 (95% CI: 2.51-10.4) and 10.70 (95% CI: 1.7-67.3) times, respectively. When the motorcycle hit another motorcycle, the risk of death increased by 2.16 times (95% CI: 1.18-3.96) compared to when the motorcycle hit a car. In those who sustained injuries to the head, thorax, and neck, the risk of death increased respectively by 46.9 (95% CI: 26.9-81), 6.06 (95% CI: 3.81-9.64), and 1.91(95% CI: 1.06-3.44) times compared to others. *Conclusion:* The risk of death was higher in older people and in those who sustained traumatic brain injury. Using air medical services may reduce the risk of death among the elderly.

Keywords: Quality of life, motorcycle traffic injuries, cohort study, Iran.

1. INTRODUCTION

Road traffic injuries (RTIs) and death are serious public health concerns in the world. Annually, > 1.35 million people die due to RTIs (World Health Organization, 2018). Among the road crashes, those related to motorcycles are specifically important and impose a high burden on low and middle income countries, such as Iran, compared to high-income countries (Bazargan-Hejazi et al., 2018; Sarsam and Khafaji, 2019). Based on the World Health Organization's (WHO) report, in 2016 in Iran, the rate of death from RTIs was 20.5 per 100,000 people, 24% of which belonged to motorcycle riders (World Health Organization, 2018). Despite the reduction in the death rate from RTIs in recent years, it is still higher in Iran than other countries. Based on the experiences of developed countries, it is possible to prevent death from RTIs (Yousefzadeh-Chabok et al., 2016). Various factors such as age (Yadollahi and Ghafarpour, 2019), severity of injury resulting from the crash, including injuries to the head when no helmet has been worn (Abedi and Sadeghi-Bazargani, 2017), not having a motorcycle license (Rezazadeh et al., 2014), factors related to pre-hospital emergency care and hospital services (e.g. staying at the hospital for >24 hours (Yadollahi and Ghafarpour, 2019), low quality of services, and reduced number of ambulances in the emergency department (Rezazadeh et al., 2014) can affect the death of RTIs, including those of motorcycle crashes. Identifying these factors can enhance the provision of services to high-risk groups and, eventually, reduce the rate of death. Previous studies in Iran have shown that the survival of the injured is affected by age and injured limb (Abedi and Sadeghi-Bazargani, 2017; Yadollahi and Ghafarpour, 2019). Implementing early interventions in the pre-hospital stage in the US (Clark, Winchell and Betensky, 2013) and China (Yu et al., 2017) has increased the survival of the people with RTIs. In motorcycle crashes, concussion is the main cause of death and injuries to lower limbs are more common than to other body parts (Fouda et al., 2016; Abedi and Sadeghi-Bazargani, 2017). In the European countries, similar to low- and middle-income countries, concussion is the main cause of death from motorcycle crashes in more than two-third of the cases (World Health Organization, 2018). Therefore, supervision on the use of safety devices, guidelines on manufacturing motorcycles with a high factor of safety, and taking effective measures in the pre-hospital and hospital stage can contribute to the prevention from death of the injured.

Previous studies in Iran on RTIs have mostly focused on fastening the seatbelt and preventing the crash. In terms of hospital services provided to the injured, studies have mostly focused on access to services and interventions to improve the outcomes (Haghparast-Bidgoli et al., 2013). However, few studies have examined the predictors of the risk of death in those injured in motorcycle crashes (Sadeghi-Bazargani, Vahidi and Abhari, 2016). Since the death of motorcycle crashes has destructive effects on the society, the present study identified the factors affecting the risk of death from motorcycle crashes in East Azerbaijan Province, Iran.

2. MATERIALS AND METHODS

This study was a part of the Persian traffic cohort study conducted based on the data of those injured in motorcycle crashes and the death data from May 2018 to December 2019. For doing this study, we collected all motorcycle injured people in this period. In Iran, any information about the fatalities of RTIs is registered in the Forensic Medicinal Organization. This information consists of police

reports, hospital reports, and information from road management offices that have been reported to the Forensic Medical Organization. This comprehensive system covers the whole country. The data on death as the result of motorcycle crashes were obtained from Forensic Medicinal Organization and the data on the injured were collected from the Iranian Integrated Road Traffic Injury Registry System (IIRTIRS) at Emam Reza and Shohada Hospitals. This system was established for the first time in collaboration with the Ministry of Health and Medical Education and WHO in these two hospitals of East Azerbaijan Province. The information available in this system has collected from different areas: the scene of the collision, emergency department, hospital admission section, forensic department and post-discharge department.

To estimate the risk of death and examine the effective factors, the key variables were extracted from the data recorded by Forensic Medicinal Organization. The time interval between the occurrence of the crash and death was taken as a dependent variable. In the studies on death from crashes, death has been regarded as due to the crash if it happens within the maximum of 30 days after it (Sadeghi-Bazargani, Vahidi and Abhari, 2016). Therefore, the data belonging to people who had survived 30 days after the crash were excluded. The independent variables were demographic variables (age, sex, marital status (single, married, divorced, widowed)), level of education (illiterate, up to 6 classes, 7-12 classes (diploma), academic education), whether light status (day, night, dusk, dawn), exact location of crash (urban, non-urban, urban roads, private roads, other roads), urban (main streets, alleys, highways, intersections, squares, detours, bridges, underpasses, private roads, boulevards, etc.), non-urban (freeways, highways, main roads, byroads, urban roads, detours, private roads, etc.), role of the injured person (rider, passenger, pillion passenger), type of the vehicle involved in the crash (car, minibus or bus, truck, bicycle, motorcycle, ambulance, and don't have any vehicle), mechanism of crash (vehicle-fixed object crash, vehicle-vehicle, crash-caused overturn, crash -caused fall, vehicle-pedestrian, vehicle-animal crash, and Exit from the road). Moreover, some variables such as type of transfer from the location of crash (by ambulance, police car, passing vehicles, etc.), place of impact (head and face, neck, thorax and abdomen, hand and arm, back and vertebral column, pelvis, legs), final cause of death (concussion, hemorrhage, multiple fractures, burning, suffocation (lack of oxygen), etc.), place of death (at the site of the crash, during transfer to the hospital, at the hospital, at home, unknown) were only filled for dead persons.

Descriptive statistics was reported for qualitative variables in the form of frequency (percentage). To evaluate the factors affecting survival, first, the bivariable Cox proportional hazard model was fitted for all the predictors. Then, the multivariable Cox proportional hazard model was fitted for the variables which were associated to the dependent variable with a p_value<=0.2 in the univariate model. The final model was fitted using backward elimination. The assumption of proportionality was examined for all the variables entering the Cox model by using the test of proportional hazard assumption. All the data were analyzed in Stata 15.0 at the significance level of <=0.05.

3. RESULTS

Descriptive findings

In total, 2008 injured people were entered into the model and analyzed, of whom 284 (14.1%) died during the study. The number of women was 12 (4.2%) and 141 (8.2%) among those who died and those who survived, respectively. The age group of 0-24 years old was the most involved age group among those who died (106, 37.3%) and those who survived (729, 43.1%). Academic education level was higher in those who survived (108, 6.35%) than those who died (8, 2.8%). In more than two-third of the motorcycle crashes, the injured party was the rider among those who died are (232, 81.9%) and those who survived (1406, 81.7%). The most frequent place of crash was non-urban roads (108, 38.1%) and urban roads (1040, 60.5%) in those who died and those who survived, respectively. The main urban roads had the highest volume of crashes in the group who died (73, 80.2%) and in the group who survived (970, 93.4%). The majority of the crashes occurring outside the cities happened on byroads and rural roads in the group who died (80, 41.6%) and the group who survived (428, 64.1%), respectively. The most common type of vehicle involved in the crash was cars, both in the group who died (114, 43.5%) and in the group who survived (988, 85.5%). In the group who died, the most common place of injury was head trauma in 261 (91.9%) and thorax in 69 (24.3%) in the group who died, and the knee and lower leg injuries in 282 (16.4%) and pelvis and thigh in 136 (7.9%) in the group who survived (Table 1).More than two-third of the crashes involved two vehicles hitting each other as the most common mechanism of the crash in the group who died (216, 77.1%) and in the group who survived (1319, 78.1%) (Figure 1).

The transfer of the injured who died was made with an ambulance in 263 cases (95.6%), with passing vehicles in 11 cases (4%), and 1 (0.4%) case with police car. The most common places of death were the hospital (175, 61.6%), site of the crash (107, 37.6%), and home (2, 0.7%) (Table 1). The most common cause of death was head trauma (150, 52.8%), mixed causes (68, 23.9%), multiple fractures (41, 14.4%), bleeding (21, 7.4%), and asphyxia (4, 1.4%) (Figure 2).

Table 1 Distribution of variables in fatal and nonfatal motorcycle crashes in East Azerbaijan, 2018-2019

variables		Nonfatal in the motorcycle injuries (n=1723)	Fatal in the motorcycle injuries (n=284)
		Frequency (%)	Frequency (%)
Age group (years)	0-24	729 (43.1)	106 (37.3)
	25-44	650 (38.4)	85 (29.9)
	45-64	238 (14.1)	70 (24.6)
	Upper 65	77 (4.5)	23 (8.1)
sex	Male	1583 (91.8)	272 (95.7)
	Female	141 (8.2)	12 (4.2)
Marital status	Single	863 (50.8)	121 (42.6)
	Married	805 (47.4)	163 (57.4)
	other	26 (1.5)	0
Education level	Illiterate	175 (10.3)	36 (12.7)
	up to 6 classes	415 (24.4)	85 (30.1)
	7-12 classes (Diploma)	1003 (58.9)	154 (54.4)
	Academic	108 (6.3)	8 (2.8)
Role of motorcycle user	Rider	1406 (81.7)	232 (81.9)
	Passenger	314 (18.3)	51 (18.1)
Types of light conditions	Day	1087 (63.5)	159 (60.9)
	Night	617 (36.1)	78 (29.8)
	Twilight	6 (0.3)	24 (9.2)
Crash Location	Inner city	1040 (60.5)	90 (31.8)
	Outer city	243 (14.1)	108 (38.1)
	Rural roads	412 (23.9)	81 (28.6)
	Exclusive roads	19 (1.1)	1 (0.4)
	Other roads	4 (0.3)	3 (1.1)
Inner-city crashes	Main road	970 (93.4)	73 (80.2)
	Byroad	69 (6.6)	18 (19.8)
Outer city crashes	Highway	74 (11.1)	33 (17.1)
	Main road	166 (24.8)	79 (41.1)
	Byroad	428 (64.1)	80 (41.6)
Crash Mechanisms	Vehicle -vehicle	1319 (78.1)	216 (77.1)
	Vehicle-fixed object	69 (4.1)	27 (9.6)
	Crash-caused Overturn	203 (12.1)	27 (9.6)
	Crash -caused Fall	33 (1.9)	6 (2.1)
	Other (Vehicle animal Vehicle-pedestrian, Exit from the road	66 (3.9)	4 (1.4)
Crash Counterparts	Don't have vehicle	355 (21.1)	49 (18.7)
	Cars	988 (58.5)	114 (43.5)
	Bicycle and Motorcycle	116 (6.8)	22 (8.4)
	Truck	215 (12.7)	70 (26.7)
	Others (ambulance, bus and minibus)	15 (0.8)	7 (2.6)
Head injury	Yes	224 (13)	261 (91.9)
	No	1499 (87)	23 (8.1)

Table 1 continue

variables		Nonfatal in the motorcycle injuries (n=1723)	Fatal in the motorcycle injuries (n=284)
		Frequency (%)	Frequency (%)
Thorax injury	Yes	36 (2.1)	69 (24.3)
	No	1688 (97.9)	215 (75.7)
Neck injury	Yes	15 (0.8)	29 (10.2)
	No	1709 (99.1)	255 (89.8)
Wrist and hand injuries	Yes	69 (4)	1 (0.3)
	No	1655 (96)	283 (99.6)
Shoulder and upper arm injuries	Yes	88 (5.1)	0
	No	1636 (94.9)	284 (100)
Elbow and forearm injuries	Yes	94 (5.5)	26 (9.2)
	No	1630 (94.5)	258 (90.8)
Hip and thigh injuries	Yes	136 (7.9)	11 (3.9)
	No	1588 (92.1)	272 (96.1)
Knee and lower leg injuries	Yes	282 (16.4)	20 (7.1)
	No	1442 (83.6)	264 (92.9)
Ankle and foot injuries	Yes	78 (4.5)	0
	No	1646 (95.5)	284 (100)
Abdomen & lower back & lumbar & spine & pelvis injuries	Yes	64 (3.7)	7 (2.5)
	No	1660 (96.3)	277 (97.5)
Place of death	At the crash scene	-	107 (37.6)
	At hospital	-	175 (61.7)
	At home	-	2 (0.7)
Mode of transport	Ambulance	-	263 (95.6)
	Passerby vehicles	-	11 (4)
	Police car	-	1 (0.4)

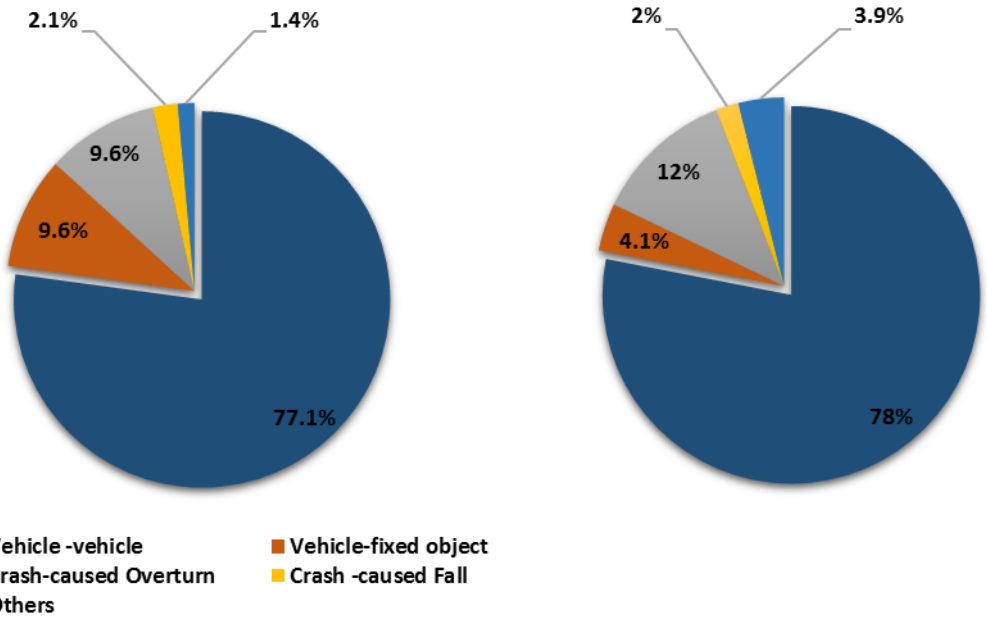

Figure 1 Distribution of crash mechanism among motorcycle user mortalities (A) and motorcycle user survivors (B) in East Azerbaijan province, Iran, May 2018 to December 2019.

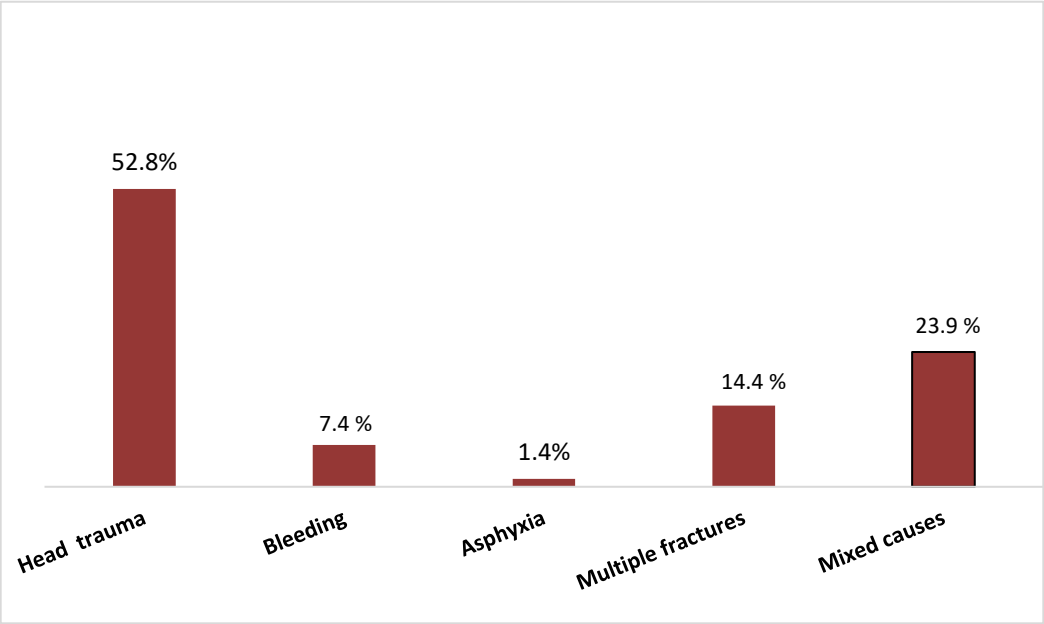

Figure 2 Distribution main cause of death among motorcycle-related fatal injury in East Azerbaijan province, Iran, May 2018 to December 2019

Bivariable analysis

Based on the bivariable Cox model, the risk of death was lower in women than in men (Hazard Ratio [HR] =0.34, 95% CI: 0.13-0.93; p= 0.03). The injured belonging to the age group of >65 years old ran the 2.68-time higher risk of death than those in the age group <25 years old (95% CI: 1.53-4.7; p= 0.001). The risk of death was higher in those who were married than those who were single HR= 1.41, 95% CI: 1.0-1.98; p=0.05). Crashes at dawn increased the risk of death 14.10 (95% CI: 7.46-26.6; p=0.001) times compared to crashes during the day. Crashes on non-urban roads increased the risk of death 3.16 (95% CI: 2.12-4.70; p=<0.001) times compared to urban roads. In non-urban crashes, the risk of death was higher on highways and byroads than the main roads by 2.83 (95% CI: 1.52-5.29; p= 0.001) and 2.56 (95% CI: 1.54-4.24; p=<0.001) times, respectively. Also, in urban crashes, the risk of death was higher on byroads than main roads by 3.53 times (95% CI: 1.86-6.7; p= 0.001). Hitting a fixed object increased the risk of death compared to two vehicles hitting each other by 3.61 times (95% CI: 2.34-5.85; p= 0.001). The risk of death was higher when two motorcycles hit each other than when the motorcycle hit a car by 2.31 times (95% CI: 1.32-4.02; p= 0.003). The risk of death was 46.90 times higher in those who sustained concussion (95% CI: 26.9-81; p=<0.001). Thorax and neck injury increased the risk of death by 11.98 (95% CI: 8.11-17.71; p=<0.001) and 10.65 (95% CI: 6.40-17.73; p=<0.001) times, respectively. However, knee and lower leg injuries decreased the risk of death, HR=0.37 (95% CI: 0.18-0.73; p=0.004) (Table 2).

Multivariable analysis

Based on the multivariable model, age was a risk factor and female sex was a preventive factor for death. The risk of death was 2.02 times higher in the elderly (95% CI: 1.08-3.77; p= 0.02) than those in the age group of 0-24 years old. Women had a lower risk of death than men, HR=0.21 (95% CI: 0.07-0.62; p=0.005). Crashes occurring outside cities were 2.1 times riskier than those happening inside cities (95% CI: 1.35-3.18; p= 0.001). Crashes at the dawn and when the motorcycle hit a fixed object increased the risk of death by 5.12 (95% CI: 2.51-10.4; p=<0.001) and 10.70 (95% CI: 1.7-67.3; p=0.01) times, respectively. The motorcycle hitting another motorcycle increased the risk of death 2.16 times (95% CI: 1.18-3.96; p= 0.01) than when the motorcycle hit a car. In those who were injured at the head, thorax, and neck, the risk of death was increased by 31.54 (95% CI: 17.5-56.6; p= 0.001), 6.06 (95% CI: 3.81-9.64; p= 0.001), and 1.91(95% CI: 1.06-3.44; p=0.03) times compared to others (Table 2).

Table 2 Bivariable and multivariable cox regression analysis of factors affecting deaths caused by motorcycle crashes in East Azerbaijan in 2018-2019

variables		Crude HR (95% CI)	P-Value	Adjusted HR (95% CI)	P-Value
Age group (years)	0-24	1	-	1	-
	25-44	0.72 (0.49-1.17)	0.215	0.58 (0.35-0.94)	0.03
	45-64	1.84 (1.19-2.85)	0.006	1.67 (1.04-2.69)	0.03
	Upper 65	2.68 (1.53-4.7)	0.001	2.02 (1.08-3.77)	0.02
sex	Male	1	-	1	-
	Female	0.34 (0.13-0.93)	0.03	0.21 (0.07-0.62)	0.005
Marital status	Single	1	-	-	-
	Married	1.41 (1.0-1.98)	0.05	-	-
	other	-	-	-	-
Education level	Illiterate	1.28 (0.76-2.18)	0.34	-	-
	up to 6 classes	1.28 (0.87-1.88)	0.21	-	-
	7-12 classes (Diploma)	1	-	-	-
	Academic	0.51 (0.18-1.38)	0.18	-	-
Position state	Rider	1	-	-	-
	Passenger	0.78 (0.48-1.25)	0.31	-	-
Light conditions of day	Day	1	-	1	-
	Night	0.97 (0.66-1.41)	0.88	0.91 (0.59-1.37)	0.65
	Twilight	14.1 (7.46-26.6)	0.001	5.12 (2.51-10.4)	<0.001
Crash Location	Inner city	1	-	1	-
	Outer city	3.16 (2.12-4.70)	<0.001	2.1 (1.35-3.18)	0.001
	Rural roads	1.26 (0.80-1.98)	0.32	0.9 (0.55-1.46)	0.68
	Exclusive roads	1.04 (0.14-7.52)	0.98	1.02 (0.13-7.95)	0.98
	Other roads	10.3 (3.23-33.06)	0.001	2.58 (0.76-8.72)	0.13
Inner-city accidents	Main road	1	-	-	-
	Byroad	3.53 (1.86-6.7)	0.001	-	-
Outer city accidents	Highway	2.83 (1.52-5.29)	0.001	-	-
	Main road	1	-	-	-
	Byroad	2.56 (1.54-4.24)	<0.001	-	-
Crash Mechanisms	Motorcycle -vehicle	1	-	1	-
	Vehicle-fixed object	3.61 (2.34-5.85)	0.001	10.7 (1.7-67.3)	0.01
	Crash-caused Overturn	1.03 (0.59-1.77)	0.91	4.95 (0.75-32.2)	0.09
	Crash -caused Fall	7.97e-15	0.99	7.44e-16	0.99
	Other (Vehicle animal Vehicle-pedestrian, Exit from the road	0.82 (0.30-2.21)	0.69	1.24 (0.32-4.7)	0.75
Crash Counterparts	Cars	1	-	1	-
	Don't have vehicle	1.55 (1.01-2.39)	0.05	0.14 (0.02-1.1)	0.05
	Bicycle and Motorcycle	2.31 (1.32-4.02)	0.003	2.16 (1.18-3.96)	0.01
	Truck	1.45 (0.85-2.47)	0.16	1.87 (1.06-3.31)	0.03
	Others (ambulance, bus and minibus)	4.02 (1.52-11.58)	0.005	0.87 (0.23-3.26)	0.84
Head injury	Yes	46.9 (26.9-81.6)	<0.001	31.54 (17.58-56.6)	0.001
	No	1	-	1	-
Thorax injury	Yes	11.98 (8.11-17.71)	<0.001	6.06 (3.81-9.64)	0.001
	No	1	-	1	-

Table 2 Continue

variables		Crude HR (95% CI)	P-Value	Adjusted HR (95% CI)	P-Value
Neck injury	Yes	10.65 (6.40-17.73)	<0.001	1.91 (1.06-3.44)	0.03
	No	1	-	1	-
Wrist and hand injuries	Yes	0.18 (0.2-1.29)	0.09	-	-
	No	1	-	-	-
Shoulder and upper arm injuries	Yes	4.30e-15	0.99	-	-
	No	1	-	-	-
Elbow and forearm injuries	Yes	1.79 (1.01-3.17)	0.05	-	-
	No	1	-	-	-
Hip and thigh injuries	Yes	0.84 (0.43-1.67)	0.63	-	-
	No	1	-	-	-
Knee and lower leg injuries	Yes	0.37 (0.18-0.73)	0.004	0.79 (0.38-1.64)	0.53
	No	1	1	1	-
Ankle and foot injuries	Yes	1.60e-15	0.99	-	-
	No	1	-	-	-
Abdomen & lower back & lumbar & spine & pelvis injuries	Yes	1.22 (0.54-2.77	0.62	-	-
	No	1	-	-	-

Abbreviations: CI; Confidence Interval, HR; Hazard Ratio

4. DISCUSSION

Based on the results, age was a risk factor and female sex was a preventive factor for death. Crashes occurring outside the cities were around two times riskier than those happening inside the cities. Crashes at the dawn and when the motorcycle hit a fixed object increased the risk of death by 5.12 and 10.70 times, respectively. The motorcycle hitting another motorcycle increased the risk of death 2.16 times than when the motorcycle hit a car. The risk of death was increased by 31.54, 6.06, and 1.91 times in those who sustained injuries to the head, chest, and neck, respectively. The risk of death was increased with age and the hazard ratio was 2.02 times higher in those aged >65 years old. This result was consistent with the results by Yadollahi (Yadollahi and Ghafarpour, 2019), Zangooee (Zangooei Dovom, Shafahi and Zangooei Dovom, 2013), and Dinh (Dinh et al., 2013). Physiological changes in the elderly, a longer time of reaction, reduced sensitivity and functioning, and poorer vehicle control skills in complicated situations make this group more vulnerable than other age groups (Jou, Yeh and Chen, 2012). Training on pre-hospital and hospital emergency care services for the injured elderly is a necessity that must receive attention by policy-makers. Women had a lower risk of death than men in motorcycle crashes, a result that is consistent with other studies (Sadeghi-Bazargani, Samadirad and Hosseinpour-Feizi, 2018; Barzegar et al., 2020). A review of previous studies shows that, in Eastern Mediterranean countries, the man-to-woman ratio in motorcycle crashes is high, 16.9:1 (Ghaffari-Fam et al., 2016) and 28:1 (Saadat, Mafi and Sharif-Alhoseini, 2011), and the motorcycle riders are mostly men, while women mostly ride pillion (Abedi and Sadeghi-Bazargani, 2017). The reason for the lower risk of women compared to men could be related to the role of these two groups on motorcycle riding. As women usually are pillions. Another reason could be related to this issue that when women are pillion on a motorcycle, the rider try to ride motorcycle slower (Lowenstein, Koziol-McLain and Glazner, 1997; Yadollahi and Ghafarpour, 2019).

In the present study, the risk of death was higher in those who sustained injuries to the head, thorax, and neck; this result is in line with the results of previous studies, in which the main cause of death in injured motorcycle riders was concussion (Passmore et al., 2010; Sadeghi-Bazargani, Samadirad and Hosseinpour-Feizi, 2018). Lower limbs are the most frequently involved body part in those who survive (Araqi and Vahedian, 2005; Hefny et al., 2012). Based on the WHO's report, wearing helmets reduced the risk of death to 40% (World Health Organization, 2018). The findings of two studies in London (Forbes et al., 2017) and Vietnam (Passmore et al., 2010) have confirmed that wearing appropriate helmets effectively reduces the impact to the head in the injured. Nevertheless, based on the review study in the Eastern Mediterranean region, using helmets varies from 6 to 90% (Abedi and

Sadeghi-Bazargani, 2017). In the present study, the percentage of wearing helmets was only 17% (n=246) in those who survived, but this percentage was unknown in those who died. Therefore, it is essential to apply further supervision on using safety devices and the guidelines on manufacturing appropriate and lightweight helmets. Moreover, offering educational courses on using helmets for riders can change their attitude and performance.

In this study, the risk of death on non-urban roads was almost twice than that on urban roads. Various factors such as high speed of the motorcycle and vehicles involved in the crash (Christie et al., 2003), different traffic composition in non-urban roads and less police control (Li et al., 2009), severity of the injury (Christie et al., 2003), and a longer time taken by the pre-hospital emergency care (Paravar et al., 2013) can increase the risk of death on non-urban roads. Based on the findings, crashes at the dawn and first hours of the morning increased the risk of death compared to other times, a result which is in line with the finding of another study in Iran (Khorshidi, Ainy and Soori, 2016). Based on the evidence, the risk of motorcycle crashes at the dawn and dusk was almost five times of the other times of the day due to poor visibility, and 21% of the cases of death resulted from impaired vision. Riding with the lights on even during the day is a method recommended by the WHO to enhance visibility as it reduces crashes by 10-15%. Moreover, using wheels of light color, light colors on the back of the motorcycles, and use clear lights for the brakes on the back of the motorcycle improves vision and reduces crashes by 15-50% (Wanvik, 2009) .

In the present study, the motorcycle hitting a fixed object increased the risk of death by 10. 70 times compared to the motorcycle hitting a passing vehicle, a result which is inconsistent with that of studies in Iran (Sadeghi-Bazargani, Samadirad and Hosseinpour-Feizi, 2018; Barzegar et al., 2020), and the US (Hayakawa, Fischbeck and Fischhoff, 2000). In these studies, the risk of death was higher when the motorcycle hit a passing vehicle. The reason for this difference in the results could be the nature of the studied samples; the target group of the cited studies was motorcycle riders who had died based on the records of Forensic Medicinal Organization, which differed from the sample of the present study. It seems that the high risk of death when hitting a fixed object is due to the high speed of the riders; the energy transferred to the fixed object at high speeds has a different pattern than when the motorcycle hits a passing vehicle; but, this needs further examination. Based on the study by Shankar, about two-third of the death cases caused by hitting a fixed object were due to high speed and the death caused by motorcycle crashes at high speed was 1.6 times more than crashes at a low speed. At high speed, the tendency to swerve from the road or hit a fixed object was higher in motorists who died (Shankar, 2001) .

Limitations: Using safety devices such as helmets was not recorded in the system of Forensic Medicinal Organization; thus, it was not possible to examine the relationship between wearing helmets and the risk of death. For those who survived, the method of transfer to the hospital was not specified. Death as the result of motorcycle crashes usually occurs during the first hours after the crashes. Nevertheless, the exact time of the crash and the exact time of death were not correctly recorded for some injured people.

5. CONCLUSION

Several factors affect the rate of survival of those injured in motorcycle crashes. Older people or those with concussion have a higher death hazard ratio. Thus, more supervision on using safety devices, having a motorcycle license, and manufacturing the motorcycle with a high factor of safety can mitigate injuries and death. Attention must be paid to the old age of the injured when taking pre-hospital measures. Also, using air medical services may reduce the risk of death among the elderly. The risk of death may be higher on non-urban roads due to the high speed and longer time it takes for pre-hospital emergency care operations. More police control in these roads, having lights on, using wheels of light colors, using light colors on the back of the motorcycle, and using translucent brake lights on the back of the motorcycle can improve the visibility of the riders by other drivers.

Ethical approval

The study was approved by the Medical Ethics Committee of Kerman University of Medical Sciences (ethical approval code: IR.KMU.REC.1397.141) and received a national code of ethics for recording the Persian traffic cohort and the IIRTIRS (code: IR.TBZMED.REC.1396.465).

Conflict of interests

The authors declare that they have no conflict of interest.

Authors' contributions

L.A.G, H. S.B, H.SH, M.B and M.N designed the study and the computational framework. L.A.G and H. S.B carried out the implementation of data gathering. Both L.A.G and H. S.B analyzed the data and L.A.G, H. S.B, and H.SH contributed to the

interpretation of the results. L.A.G wrote the paper with input from all authors. All authors provided critical feedback and helped shape the final manuscript

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Data and materials availability

All data associated with this study are present in the paper.

Peer-review

External peer-review was done through double-blind method.

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