

Factors Affecting the Severity of Traffic Accident Injuries; a Cross-Sectional Study Based on the Haddon Matrix

Omid Garkaz ¹, Hamid Reza Mehryar ², Hamid Reza Khalkhali ³, Shaker Salari Lak ⁴ *

¹ MSc of Epidemiology, Shahroud University of Medical Sciences, Shahroud, Iran

² Assistant Professor of Emergency Medicine, Urmia University of Medical Sciences, Urmia, Iran

³ Professor of Biostatistics, Urmia University of Medical Sciences, Urmia, Iran

⁴ Associate Professor of Epidemiology, Department of Public Health, Islamic Azad University, Tabriz Branch, Tabriz, Iran

* **Corresponding Author:** Department of Public Health, Islamic Azad University, Tabriz Branch, Tabriz, Iran.

Email: salari@iaut.ac.ir , salarilak@yahoo.com

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Abstract

Background: Based on the Haddon matrix, several factors such as environment, host, and agent can affect the severity of traffic-related injuries.

Objectives: This study aimed to determine the factors affecting the severity of injuries due to traffic accidents using the Haddon matrix.

Methods: In this cross-sectional study, all traffic accident victims (n=2015) referred to Imam Khomeini Hospital in Urmia during 2015-2016 were selected by the census method. Demographic data of the patients and data regarding Haddon risk factors was collected and then analyzed by descriptive statistics, chi-square test, and multivariate logistic regression using the SPSS 18 software.

Results: The mean age of the participants was 33.63±18.53 years. Most of the victims of traffic accidents were male (age range, 17-30 years) with severe and critical injuries. The most common mechanisms of injury were car-pedestrian collisions (27.9%), car overturning (31.1%), and collisions between two cars (26.3%). Violation of speed limit (73.2%) and violation of right-of-way (17.9%) were the most common moving violations. Additionally, the results of the multivariate analysis regarding vehicle safety devices showed that there was a significant relationship between the time and location of the accident and the severity of the injury ($p<0.001$).

Conclusion: The findings of this study reveal that many factors, including using vehicle safety tools and time and location of the accidents have been implicated in the severity of accident-related injuries. Hence, appropriate planning and training and national and international measures can be helpful in reducing injury severity.

Keywords: Wounds, Injuries, Traffic accidents, Risk factors.

Introduction

Although industrial development in the world has created relative prosperity for human beings, it has also been effective in creating new problems such as traffic accidents. Such events have become one of the three most important social, economic, and health risk factors affecting public health. Of all accidents, traffic accidents are particularly important in developing countries such as Iran, because they cause serious damage to the national economy in addition to many deaths and injuries annually (1). Every year, 1.2 million people are killed in road accidents and more than 50 million are injured or disabled. Unless action is taken, it will reach 1.9 million by 2020. Eighty-five percent of deaths and 90% of disabilities occur in middle- and low-income countries. Many victims of traffic accidents have never had a car, and many are children (2-5).

New technologies are increasing the safety of roads every day, and their impact on human behavior and how they

reduce the risk of accidents must be investigated. Understanding human causes and their impact on reducing traffic accidents is a very important subject. Studies show that three factors, the driver (human factors), the vehicle, and the environment are involved in the occurrence of traffic accidents. A study conducted in the United States found the role of the human factor was 57% and the role of environmental and road factors was 34%, of which 30% was common between the environment and humans, and only 4% was related to the environmental conditions (6, 7).

Several studies were conducted to examine human factors, such as drowsiness during driving, gender, age, smoking; vehicle-related factors, including not using the seat belt, speed while driving, and the nature of the vehicle; and the environmental factors of day, week, travel time, driving and road design, and traffic crossing laws which are the major causes of traffic accidents. Various studies have shown that pedestrians and motorcyclists are more vulnerable to traffic

accidents. In a cross-sectional study that evaluated traffic accidents over a year, more than 98.8% of victims were under the age of thirty (7-13). Tavakoli *et al.* conducted a study in Kerman and reported that young drivers were found to be more vulnerable to road accidents (14).

In a study conducted in Khuzestan, not using the seat belt was the most prevalent cause of road injuries among people. In Rostami's study carried out in Ardabil, the main cause of death was multiple injuries and brain injuries (15, 16). Worldwide research shows that men have higher rates of traffic accidents than women. Additionally, the results of a study conducted in the United States demonstrated that the most common causes of traffic accidents are high speed, crossing unauthorized areas, risky driving for fun and entertainment, and slipping between cars. In addition, the results of a study performed in Iran showed that the most common causes of fatal accidents are related to human risk factors, and the prevalence of fatal traffic accidents is higher in inexperienced drivers than in people with more driving experience (17, 18).

Evaluation systems like the Haddon matrix are available to determine the vehicle-related, human, and environmental factors in traffic accidents (19). The Haddon matrix was first introduced by William Haddon in the United States in 1973; in it, the interaction of the three factors of human, vehicle, and environment in the occurrence of events was demonstrated. This model considers three stages of prevention before, during, and after traffic accidents. The Haddon model provides an opportunity to examine the effects of interventions on the behavioral, road-related, and vehicle-related factors that influence the number and severity of traffic accidents. In this model, we can identify the most important sources of design errors or failures that have resulted in serious accidents, deaths, and injuries (20, 21).

Because of the importance of accidents, especially traffic accidents, their negative effects on the health of human society, and the importance of investigating this issue in the

country due to the considerable frequency and consequences of traffic accidents such as disability and death, the aim of the present study was to investigate the factors affecting the severity of traffic accident injuries using the Haddon matrix in Urmia city of West Azerbaijan Province.

Materials and Methods

In this cross-sectional study, all trauma victims (n=2015) referred to Imam Khomeini Hospital in Urmia, Iran, during 2015-2016 were selected by the census method. To collect data, some inclusion and exclusion criteria were first considered. Inclusion criteria included injuries due to traffic accidents, trauma survivors on admission to hospital, injury data recording in hospital trauma system, and at least one injury to a part of the body. Exclusion criteria included non-traffic accident victims, victims of air, rail, and marine accidents, and lack of data or incomplete data. In total, 2015 patients met the inclusion criteria. Demographic data collected included age, gender, type of accident, accident location, accident time, safety tools, and moving violations. Severity of injury was calculated using the injury severity score (ISS). Traumas with a score of 1-9 were categorized as mild, 10-15 as moderate, 16-25 as severe, and over 25 as very severe and critical (22). The Hudson matrix was defined based on factors affecting the occurrence of traffic accidents in three groups related to host, agent, and environment (Table 1). The demographic data of the patients and data regarding risk factors based on the Haddon matrix were extracted and recorded by trained specialists using police and medical files as well as asking the patient or their relatives. Then, the obtained data was analyzed using descriptive statistics (frequency, mean, and standard deviation), chi-square, and multivariate logistic regression tests by SPSS 18 software; $p < 0.05$ was considered as the level of significance. To observe patient rights, all researchers kept patients' information confidential.

Table-1. Effective risk factors in the occurrence of an accident based on the Haddon matrix

Category	Risk factors
Host	Age, using safety tools (helmet in motorcycle riders, seat belt in drivers), and moving violation (violation of speed limit, undertaking, crossing over a center divider, violation of right-of-way)
Agent	Accident type (pedestrian car, pedestrian motorcycle, 2 motorcycles, 2 cars, falling down)
Environment	Safety of the accident location (pedestrian line or footbridge, traffic light, guard rail, proper road construction, proper lighting), weather conditions at the location (time of the accident), place of accident (traffic or road)

Results

A total of 2015 patients with accident-related trauma with a mean age of 33.63 ± 18.53 years and mean injury severity of 16.16 ± 48.48 were included in this study. Among them, 1474 (73%) patients were male. Most traffic accidents resulting in hospitalization were due to car-pedestrian accidents with 563 cases (27.9%) and car-motorcycle accidents with 232 cases (11.5%). Most traffic accidents had occurred outside the city with 1133 cases (56.2%) and between the hours of 3 p.m. and

8 p.m. with 797 cases (39.6%). Furthermore, 1648 (81.3%) trauma victims had used safety equipment; car drivers had used safety equipment more than motorcyclists. The most common driving errors that caused collisions were unauthorized speed with 1477 cases (73.2%) and violation of the right of way with 361 cases (17.9%). In addition, 700 (34.7%) were injured severely or very severely, while 515 (25.5%) were moderately injured (Table 2).

Table-2. Baseline Characteristics of Injured Persons Referred to Imam Khomeini Hospital in 2016

Characteristics	Category	Frequency (%)
Age (years)	1-16	323 (16)
	17-29	694 (34.4)
	30-39	362 (18)
	40-49	262 (13)
	50-65	262 (12.3)
	>65	127 (6.3)
Gender	Man	1474 (73.2)
	Woman	541 (26.8)
Type of accident	Pedestrian with car	563 (27.9)
	Motorcycle with car	232 (11.5)
	Overturning	626 (31.1)
	Two cars collision	530 (26.3)
	Two Motorcycles collision	22 (1.1)
	Motorcycle with pedestrian	31 (1.5)
Accident location	Inside the city	880 (43.7)
	Outside the city	1133 (56.2)
Time of accident (hour)	8 am - 2 pm	659 (32.7)
	3 am - 8 pm	797 (39.6)
	21 pm-8 am	559 (27.7)
Injury score*	Mild (1-9)	800 (39.7)
	Moderate (10-15)	515 (25.6)
	Severe (16-25)	359 (17.8)
	Very severe (>25)	341 (16.9)
Use of safety tools	Seat belt	1378 (68.3)
	Helmet	263 (13)
Moving violation	Violation of speed limit	1477 (73.2)
	Violation of right-of-way	361 (17.9)
	Crossing over a center divider	95 (4.7)
	Undertaking	18 (0.9)

*Based on injury severity score (ISS).

Accidents with severe and very severe injuries had occurred in unsafe regions with 38 (11.1%) and 111 (33.7%) cases, respectively. Most accidents with mild injuries with 709 (91.5%) cases and moderate injuries with 427 (86.6%) had occurred in safe regions. Most of the accidents resulting in

severe injuries with 207 (57.7%) cases and very severe injuries with 213 (62.5%) cases occurred outside the city. Most severe and very severe injuries occurred between 3 pm and 8 pm and in the age group of 17-30 years old. The most severe injuries with 264 (0.77%) cases and very severe injuries with 259

(77.5) cases were due to moving violation of unauthorized speed. The most common mechanisms of accidents resulting in very severe injuries were overturning with 103 (30.3%) cases, pedestrian-car collision with 92 (27.2%) cases, the

collision of two cars with 77 (22.6%) cases, car-motorcycle collision with 52 (3.3%) cases, and motorcycle-pedestrian with 9 (2.6%) cases (Table 3).

Table-3. The Effect of Haddon Matrix Factors on Injury Severity

Variables				injury severity based on ISS*				P-Value
				Frequency (%)				
				Mild	Moderate	Severe	Very severe	
Environment	Accident location	safety	Yes	709 (91.5)	427 (86.6)	305 (88.9)	218 (66.3)	0.001
			No	66 (8.5)	66 (13.4)	38 (11.1)	111 (33.7)	
	Accident location		Inside the city	366 (45.8)	234 (45.5)	152 (42.3)	128 (37.5)	0.053
			Outside the city	433 (54.2)	280 (54.5)	207 (57.7)	213 (62.5)	
	Time of accident (hour)		8 am-2 pm	245 (30.6)	164 (31.8)	124 (34.5)	126 (37)	0.225
			3 pm- 8 pm	332 (41.5)	199 (38.6)	131 (36.5)	135 (39.6)	
			21 pm-8 am	223 (27.9)	152 (29.5)	104 (29)	80 (23.5)	
Host	Age		1-16	133 (16.6)	94 (18.3)	61 (17)	35 (10.3)	0.035
			16.1-30	282 (35.3)	172 (33.4)	116 (32.3)	124 (36.4)	
			30.1-40	145 (18.1)	96 (18.6)	52 (14.5)	69 (20.2)	
			40.1-50	110 (13.8)	57 (11.1)	45 (12.5)	50 (14.7)	
			50.1-65	86 (10.8)	69 (13.4)	53 (14.8)	39 (11.4)	
			>65	44 (5.5)	27 (5.2)	32 (8.9)	24 (7)	
	Use of safety tool (seat belt)		Yes	586 (75.5)	367 (74.6)	253 (74)	172 (51.7)	0.001
			No	54 (7)	40 (8.1)	32 (9.4)	91 (27.3)	
	Helmet		Yes	120 (15.5)	65 (13.2)	44 (12.9)	34 (10.2)	
			No	16 (2.1)	20 (4.1)	13 (3.8)	36 (10.8)	
	Moving violation		Violation of speed limit	582 (74.9)	372 (74.8)	264 (77)	259 (77.5)	0.922
			Violation of right-of-way	150 (19.3)	93 (18.7)	59 (17.2)	59 (17.7)	
			Crossing over a center divider	40 (5.1)	27 (5.4)	12 (3.6)	12 (3.6)	
			Undertaking	5 (0.6)	5 (1.0)	4 (1.2)	4 (1.2)	
Factor	Mechanism of injury	Car-pedestrian collision	213 (26.8)	149 (29.2)	109 (30.4)	92 (27.1)	0.001	
		Car-motorcycle collision	61 (7.7)	69 (13.5)	50 (14)	52 (15.3)		
		Overturning	251 (31.6)	169 (33.1)	103 (30.3)	103 (30.3)		
		Car-car collision	255 (32.1)	111 (21.7)	87 (24.3)	77 (22.6)		
		Motorcycle-motorcycle collision	6 (0.8)	6 (1.2)	3 (0.8)	7 (2.1)		
		Motorcycle-pedestrian collision	9 (1.1)	7 (1.4)	6 (1.7)	9 (2.6)		

* ISS: injury severity score

According to the results of multivariate logistic regression analysis, there was a significant relationship between injury severity, using safety tools, and safety of the accident location. Not using seat belt and not using helmet increased the risk of injury by 4 and 5 times, respectively (not using seat belt = 4.97, 95% CI: 3.62, 6.84, $p = 0.001$) and (not using helmet = 5.05, 95% CI: 3.17, 8.06, $p = 0.001$). In addition, the

severity of the injury was reduced to 0.64 between the hours of 8 am and 21 pm (from 8 am to 21pm = 0.64, 95% CI: 0.46, 0.89, $p = 0.009$). Finally, traffic accidents occurring outside the city increased the risk of injury more than 1-fold. (Outside the city = 1.30, 95% CI: 1.01, 1.68, $p = 0.04$). Female gender and type of accident are also predictive factors.

Table-4. Relationship between Injury Severity and Study Variables according to Multivariate Logistic Regression Analysis

Variables	OR	95%CI		P-value
		Lower	Upper	
Use of safety tool	*Using safe seat belt	1	-	-
	Not using safe seat belts	4.979	3.62	0.001
	Using safe helmet	1.043	0.70	0.834
	Not using the safe helmet	5.059	3.17	0.001
Time of accident	*8 am-2 pm	1	-	-
	3 pm-8 pm	0.826	0.621	0.189
	8 pm- 21 pm	0.646	0.466	0.009
Location of accident	*Inside the city	1	-	-
	Outside the city	1.303	1.011	0.041
Gender	*Male	1	-	-
	Female	0.820	0.614	0.180
Type of Crash	*Pedestrian-car collision	1	-	-
	Overturning	0.989	0.720	0.989
	Car-car collision	0.846	0.598	0.344
	Motorcycle-car collision	0.616	0.338	0.112
	Motorcycles-motorcycle collision	0.497	0.095	0.407
	Motorcycle-pedestrian collision	1.101	0.422	0.844

*Reference

Discussion

The results of the present study showed that more than 70% of the injured people were male and from the age group of 17-30 years. The severity of traffic-related injuries is associated with factors such as safety of accident location, age, using safety tools, and mechanism of injury. Additionally, the mean scores of injury severity were moderate and severe in this study, which is consistent with the results of similar studies (7, 22-26). This injury severity can be primarily due to young men's sensation-seeking and risky driving behaviors, having greater access to a vehicle than before, as well as due to the cultural conditions of the society.

The findings of this study indicate that most accidents occur between 3 am and 8 pm, which was in line with the studies of Zarger et al. and Yang et al. (27,28). This is probably due to the closure of offices and most people traveling to their homes, and at dusk, the departure of people for shopping and leisure. Moreover, most accidents occur outside the city, which is inconsistent with the studies conducted by Rodriguez et al. (29) and Melander et al. (30). This issue is probably due to non-compliance with the driving rules and poor control of driving performance outside the cities.

In this study, the most frequent mechanism of traffic accidents was overturning following a collision with a pedestrian, which is not in line with the results of other studies. Most previous studies have stated that motorcycle accidents were the most frequent mechanism of accidents (31-33). This issue can probably be due to a lack of attention by drivers to the traffic rules and low pedestrian safety when crossing the street. Proper training and planning are required to reduce these accidents.

As a further matter, most severe injuries in motorcycle riders which led to death were due to the lack of using helmets and other safety tools and the severity of the accidents, not because of the frequency of accidents. Motorcyclists who do not wear a helmet while driving are three times more likely to be exposed to concussion and head injury compared to those who choose to wear a helmet; using a safety helmet can reduce the rate of deaths due to severe head injuries by 20%-45% (34-36). Thus, proper training and the observance of safety regulations by motorcyclists can reduce traffic accident-related injuries.

The results of the current study also showed that most of the injured people were car drivers and passengers who had used a seat belt during the accident; this finding is not in agreement with those of previous studies (37,38), and can be

due to the lack of proper training and not observing traffic regulations by the victims.

Furthermore, the findings of the present study revealed that most moving violations in traffic accidents are related to violations of speed limit (unauthorized speed) by the drivers, which is inconsistent with the findings of similar studies (39, 40). This result may be attributed to differences in the driving culture and behavior in different provinces.

In this study, the safety of the accident location, using safety tools, and the mechanism of injury (the type of accident), especially overturning, were significantly correlated with the severity of the injury, which is consistent with the results of previous studies (7, 8, 28, 41). This indicates that type of accident and observing traffic safety rules can play significant roles in reducing both the severity and the incidence rate of the injury.

Moreover, the use of safety tools, time, and location of the accidents can be related to the severity of the injury; not using safety tools like safety helmets can significantly increase the risk or severity of injuries, which is in line with the findings of previous similar studies (24,36,42).

One of the strengths of this study is that no study has been conducted in this respect at the provincial level, especially with this large sample size per year. The limitations of this study were incomplete registration of patients' records and the lack of enough cooperation of related organizations. It is recommended that some training programs and planning be performed to eliminate or mitigate environmental, host, and agent factors which can reduce severe and critical injuries in the first phase of accidents, and subsequently, may result in reduced financial and health costs of traffic accidents. Community education using training programs and incentive/punishment programs, improving road conditions, eliminating provincial or country accidents, revising the minimum permitted driving age, planning special traffic rules for motorcyclists, reinforcing traffic restrictions, and controlling traffic in accident-prone times (3-8 pm) can be helpful in this regard. Furthermore, it is recommended that more general and national studies with larger sample sizes be designed to identify the correlations of these factors more accurately and decrease traffic accidents and, consequently, injuries resulting from them.

Conclusions

The findings of the present study revealed that many factors are influential in the severity of injuries due to accidents based on the Hudson matrix. Moreover, factors such as wearing a seat belt or helmet, time of the accident (between 21 pm and 8 am), and location of the accident multiplied the risk of injury. Hence, proper planning and training can reduce injuries due to accidents.

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Authors' Contribution

All authors pass the four criteria for authorship contribution based on the International Committee of Medical Journal Editors (ICMJE) recommendations. OG contributed in performing the study and developing the concept of the study; HRM had assistance in performing methodology and discussion sections of the study; HRK contributed in performing statistical analyses; and SSL assisted in performing the study as an adjunct researcher.

Conflict of Interests

The authors declared no potential conflict of interests with respect to the research, authorship, and/or publication of this article.

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