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Incidence of Road Traffic Injuries in the Provinces of Iran in 2019: A Multilevel Analysis

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Abstract

Background: This study investigated the influence of age, gender and geographical region on the incidence of four types of injuries among pedestrians, cyclists, motorcyclists and motor vehicle drivers in Iran. The geographical correlation between the different provinces of the country was also examined.

Objectives: The present study aimed to investigate 4 common type of road traffic injuries by provinces in Iran.

Methods: The data was taken from the Global Burden of Disease (GBD) study. The data were analyzed in terms of age group, gender and type of injury in different provinces, and the effect of geographical region on the incidence of RTIs were investigated through a multilevel analysis. Provinces were included in the model as random intercepts, and Moran's I test was used to examine geographic correlation and identify hot spots and cold spots. A significance level of 5% was used for all tests.

Results: Elderly people were the main victims of pedestrian accidents, and young people were most frequently injured in cycling accidents. On the other hand, adults were the most frequently injured age group in motor vehicle accidents. Men were injured more often than women in all four types of injury. Although the injuries were not related to the province where the accident occurred, the geographical distribution of injuries caused by cyclists showed a geographical correlation, with Sistan and Baluchistan (southeast) and Tehran (the capital) being the areas with the highest and lowest risk of these types of injuries, respectively.

Conclusion: According to the results of this study, the causes of different types of road traffic injuries are very different for different age groups, genders and geographical areas. Therefore, different plans should be developed for each type of injury in order to prevent road traffic accidents.

Keywords: Incidence, Iran, Traffic accident

1. Background

Road Traffic Injuries (RTIs) are one of the leading causes of death in all age groups. According to the World Health Organization, more than one million people die each year as a result of road traffic injuries, and about 50 million people are injured (1, 2).

RTIs can cause many types of injuries to motorcyclists, cyclists, drivers and passengers of motor vehicles and pedestrians, each of which can lead to death or serious injury. According to the studies conducted in Iran, Iran will rank third among high middle-income countries in terms of the number of deaths caused by RTIs in 2030. In Iran, most road accidents occur among motorcycle and car drivers, which account for 77% of road accidents (3, 4).

One of the main victims of RTIs are pedestrians, who suffer numerous injuries. It is estimated that around 270,000 pedestrians worldwide die each year in road accidents, most of which occur close to their homes. Of the various age groups, children and the elderly are the most frequently injured in road accidents (5).

Motorcyclists are among the most vulnerable people in relation to RTIs. The mortality rate of motorcyclists in middle-income EMRO countries is around 6%, while in high-income countries it is 4%. Another critical point is the 20 times higher risk of death per kilometer traveled for motorcyclists compared to other vehicles, indicating a very high risk of death due to traffic accidents (6).

Cycling is one of the most influential sports in maintaining health. Children and adolescents are among those who are interested in this sport, but controlling the RTIs caused by it is a major challenge in managing traffic accidents and incidents. A Australian study has shown that the risk of accidents among cyclists is 0.3 per 1,000 kilometers traveled, which is not alarming, but considering that children are the main victims, head injuries with subsequent serious problems cannot be ruled out (7).

Motor vehicle accidents are increasing every year and this type of injury has become the leading cause of death in developing countries, so much so that the

WHO has declared it a critical public health problem. Traffic accidents involving motor vehicles have caused serious physical injuries to many people. Severe traumatic brain injury (TBI), impact to the head resulting in a prolonged coma, and spinal cord injury (SCI) are among the most serious injuries that can be caused by this type of accident, which, if not fatal, will leave irreparable damage (8).

2. Objectives

Since Iran is one of the EMRO countries with a high rate of RTIs (9), this study aims to investigate the rate of traffic accidents among pedestrians, motorcyclists, cyclists, as well as motor vehicles in different age and gender groups, considering the effects of different provinces. Another aim of this study is to investigate the geographical and syntactic autocorrelation for the distribution of all the mentioned events.

3. Methods

3.1.GBD Database

The Global Burden of Disease (GBD) study is a regional and global program of the research community that examines the burden of disease, risk factors and various health outcomes. This study used the updated data (2019) on road traffic injuries by age group, gender, and accident type (pedestrians, cyclists, motorcyclists, and motor vehicles) was used, which were extracted and analyzed separately for each province.

3.2. Descriptive Analysis

To describe the data, the incidence for each type of road traffic accident in the reported age groups was given on the basis of 100,000 people and with a 95% confidence interval. Arc Map GIS version 10.1 was also used to show the geographical distribution of accidents and the incidence of each type of accident in the different provinces using quartiles (Q1-Q4). Quartile classification is one of the statistical classification techniques in which the data is sorted based on the value from low to high and finally the first, second, third and fourth quartiles contain 25%, 50%, 75% and 100% of the values respectively.

3.3. Multilevel analysis

Given the large number of provinces and their internal correlation, to control for the effect of provinces when examining the influence of age and gender on the frequency of RTIs, the effect of provinces was randomly entered into the model by using multilevel modeling instead of creating a dummy variable. In this type of modeling, the variance of traffic accident frequency in different provinces is used instead of including each province effect in the model. A significant level of 5% was considered.

3.4. Spatial Autocorrelation

The Moran's I test was used to check the correlation between the different provinces in terms of their RTI incidence and to see if there is a clustering of this type of injury in other provinces. If significant, the hot and cold clusters of RTI incidence are identified. A significance level of 5% was used for this test.

4. Results

The results of the study of pedestrian injuries in Iran show that the highest incidence is among males in the 20-29 and 70 + age groups, namely 399 and 335 cases per 100.000 people, separately. In addition, the highest incidence is in women in the 60-64, 69-65 and over 70 age groups, with 245, 292 and 290 cases per 100,000 people respectively. Among cyclists, another type of RTI, the highest incidence was in both genders in the 10-24 age group, with 392 cases in males and 261 cases in females per 100,000 people.

Among motorcyclists, the highest incidence was in men and women over the age of 70, with 355 and 128 cases per 100,000 people respectively. As for the incidence of motor vehicle accidents, it was highest among men in the 40-45 age group with 506 cases, in contrast to women who were mostly injured in the 65-69 age groups with 291 cases per 100.000 people (Table 1).

The results of multilevel modeling showed that provinces have no effect on the frequency of RTIs. On the other hand, taking into account their random effect in the model, gender and age significantly ($P<0.01$) increase the frequency of RTIs. Among pedestrians, women were injured 36% less than men, and the over-70 age group suffered 27 times more injuries than the under-5 age groups.

Among cyclists, the frequency of injury among women was 40% lower than among men. In addition, the 10-24 age groups suffered more than 4 times as many injuries as the under- 5 age groups. Female motorcyclists were injured 54% less than males, and the over-70 age group suffered more than 4 times as many injuries as the under-5 age group (Table 2). Finally, the study of the incidence of motor vehicle injuries found that females were injured 28% less than males. The reported incidence in the 40-44, 49-45 and 35-39 age groups is approximately 18, 17 and 16 times higher, respectively, than in the under-5 age group. Further details can be found in Table 2.

Investigating the geographical distribution of injuries in Iran was another aim of this study. According to the results, the incidence of pedestrian injuries was highest in the provinces of Sistan and Baluchistan (Southeast), Ilam, Central and Hamadan (West) and the northern provinces. It was not significant ($P=0.76$) (Figure 1_A).

Table 1. Incidence of Road Injuries in Iranian people by gender and Age (per 100,000)

Age Groups	Type of Road Injury in men				Type of Road Injury in women			
	Pedestrian	Cyclist	Motorcyclist	Motor vehicle	Pedestrian	Cyclist	Motorcyclist	Motor vehicle
<5	11 (5 21)	84 (42–145)	57 (29–103)	21 (9-42)	13 (6-23)	64 (32-112)	52 (26–93)	24 (11-47)
5-10	56 (27–105)	234 (122-381)	89 (41–103)	89 (42-165)	50 (24–93)	177(91–290)	73 (33–137)	94(45 -169)
10-24	312 (192-496)	392 (243-599)	236 (142-236)	345 (222-560)	174 (106-285)	261 (157-403)	75 (43-123)	252(117 – 391)
25-29	399 (203–686)	304 (146-535)	189 (94–163)	428(209-725)	174 (88-310)	161 (76–286)	43 (20–81)	241(124-407)
30-34	329 (172–572)	244(117–443)	133(60–244)	438(221-744)	118 (60–211)	105 (48–195)	29 (12-49)	201(103-341)
35-39	321 (161–555)	234(105-404)	125 (59–218)	489(254-788)	105 (51–189)	91 (40–167)	27(11-49)	205(107-331)
40-45	302 (152–518)	214 (98-380)	117 (54-214)	506(259-811)	115 (57-205)	93 (39–173)	28 (12 – 56)	248(128-404)
45-49	258 (132 -441)	176 (82–323)	95 (48-171)	437(256-706)	139 (70–234)	92 (39-184)	28 (12 -54)	281(172-445)
50-55	236 (109–410)	138 (69–256)	93 (45–163)	338(172-567)	166 (78–291)	84 (38-166)	32 (14 -62)	276(146-447)
55-59	235 (115–406)	112 (54-203)	113 (53–205)	284(148-461)	199(99-338)	73(32–140)	40 (17 -76)	275(150-444)
60-64	246 (125 -441)	102 (45-191)	152 (77–262)	255(128-440)	245 (128-429)	73(30-142)	55 (26-102)	287(150-485)
65-69	251 (133–418)	101 (46-176)	199 (105-33)	218(111-374)	292(161-474)	81(33–143)	82 (40-151)	291(161-465)
70<	335 (223-467)	103 (65–155)	355 (143–501)	237(152-354)	290(190–413)	70 (39-113)	128(82-192)	206(128-305)

Table 2. Multilevel analysis to predict effect of Age and sex on Road Injuries by controlling the effect of province

Parameters	Pedestrian	Cyclist	Motorcyclist	Vehicle
Fixed effects	**RR (%95 CI for RR)**			
Sex*				
Male (Ref)				
Female	0.64 (0.63, 0.65)	0.60 (0.58, 0.61)	0.36 (0.35, 0.37)	0.72 (0.71, 0.73)
Age**				
<5 (Ref)				
6-10	4.48 (4.13, 4.85)	2.75 (2.65, 2.84)	1.45 (1.39, 1.52)	4.15 (3.91, 4.41)
10-24	20.82 (19.34, 22.40)	4.35 (4.21, 4.50)	2.87 (2.75, 2.98)	13.84 (13.10, 14.61)
25-29	24.68 (22.93, 26.55)	3.13 (3.03, 3.24)	2.17 (2.08, 2.26)	15.42 (14.60, 16.28)
30-34	19.66 (18.26, 21.17)	2.37 (2.28, 2.45)	1.51 (1.45, 1.58)	15.01 (14.21, 15.84)
35-39	19.13 (17.77, 20.59)	2.21 (2.13, 2.29)	1.42 (1.35, 1.48)	16.59 (15.71, 17.51)
40-44	18.80 (17.47, 20.24)	2.11 (2.03, 2.18)	1.35 (1.29, 1.41)	18.07 (17.12, 19.07)
45-49	17.64 (16.38, 18.99)	1.85 (1.78, 1.91)	1.14 (1.08, 1.19)	17.19 (16.29, 18.15)
50-54	18.00 (16.71, 19.38)	1.54 (1.48, 1.60)	1.14 (1.09, 1.20)	14.83 (14.05, 15.66)
55-59	19.56 (18.17, 21.05)	1.28 (1.22, 1.33)	1.40 (1.33, 1.46)	13.56 (12.85, 14.32)
60-64	22.03 (20.47, 23.71)	1.21 (1.16, 1.25)	1.89 (1.81, 1.97)	13.00 (12.31, 13.73)
65-69	24.08 (22.38, 25.92)	1.24 (1.19, 1.29)	2.57 (2.47, 2.68)	12.08 (11.44, 12.76)
>70	27.26 (25.34, 29.33)	1.20 (1.15, 1.24)	4.44 (4.28, 4.61)	10.40 (9.84, 10.99)
Random effects		**Variance (SD)**		
Intercept	0.036 (0.19)	0.006 (0.08)	0.024 (0.15)	0.029 (0.17)

RR: Risk ratio, CI: Confidence interval, SD: Standard deviation, * p<0.01, **p<0.01

Sistan and Baluchistan (Southeast) and Golestan (Northeast) were the two provinces with the highest reported incidence of cyclist injuries, while Qom, Tehran (the capital), Alborz, and Qazvin provinces had the lowest incidence. There was a geographical correlation in the distribution of the incidence of this type of injury, and the provinces were identified as hot spots and cold spots on the map (P<0.001) (Figure 1_B).

The incidence of motor vehicle injuries was high in almost all provinces of Iran, but it was higher in some southern and western provinces and in Mazandaran province (north) than in the others. The geographical correlation was not statistically significant (P = 0.17) (Figure 1_C). Although the incidence of motorcycle accidents was higher in Markazi and Southern provinces than in the other provinces, the geographical distribution showed no geographical correlation for the incidence in Iran (P=0.13), (Figure 1_D).

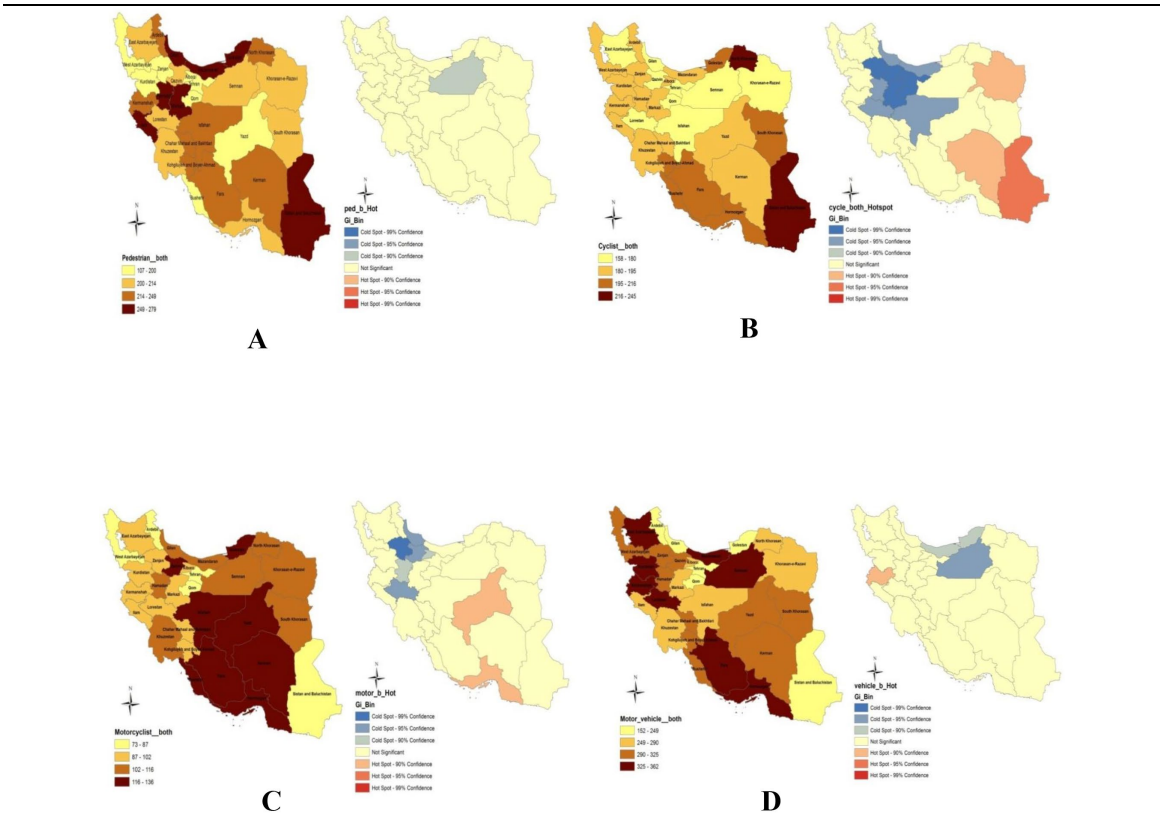

Figure 1. Spatial distribution of Pedestrian(A), Cycle(B), Motorcycle(C), and Motor vehicle(D) incidence in provinces of Iran in 2019

5. Discussion

The results of this study showed that the elderly were the most injured among pedestrians and motorcyclists, that young people were the main victims of injuries among bicyclists, and that most motor vehicle injuries occurred among middle-aged people (40-45 years); the incidence of all incidents was significantly higher among males than females. Although the different provinces did not differ in terms of overall accident location, the geographical correlation in the incidence of cyclist injuries was significant, with more accidents occurring in some provinces and fewer in others.

RTIs can occur in all age and gender groups, but some of these groups are more exposed to a particular type of injury due to their specific conditions; For example, children and older people are always more susceptible to most health consequences; this study showed that most injuries to pedestrians and motorcyclists occurred in older people. A study in Italy also investigated the importance of this type of injury in children and the elderly, and it appears that the elderly may be the main victims for various reasons, such as skeletal and muscular disorders or mental disorders and balance problems (10).

As cycling is one of the most popular sports and hobbies among teenagers, they are also more likely to be affected by injuries. Various studies show that teenagers are more at risk than others as they use bicycles more than others, usually without observing safety precautions such as wearing helmets (11).

Motor vehicles are one of the leading causes of RTIs worldwide, resulting in serious injuries, including death and disability, and occurring in almost all age groups. However, as adults usually have to drive more due to their work, they could be one of the risk groups for the occurrence of traffic accidents. A study on the causes of road traffic accidents has shown that adults and women are most frequently affected by such injuries (12).

Geographical characteristics, road infrastructure, laws and traffic control mechanisms such as speed cameras, fines as well as population density and traffic patterns can cause geographical patterns for all types of traffic injuries (13). These geographic correlations can follow a similar pattern, creating hot spots (high risk) and cold spots (low risk) for RTI occurrence. In this study, the geographic correlations in 4 types of traffic accidents were examined and it was found that the geographic correlation in bicycle accidents was significant.

In Tehran (the capital) and surrounding cities, the risk of injury from cycling was lower than in the province of Sistan and Baluchistan (southeast); one of the main reasons could be the lack of proper infrastructure and urban bike lanes, as well as the use

of helmets in this province, which has led to an increase in injuries among cyclists. Tehran is one of the most modern cities in Iran where there are special places for cyclists (14).

The highest rate of motor vehicle-related injuries is in western Iran. In this geographical area, there is an important transit road used for the international trade of goods and the high volume of traffic is observed there. In addition, the road infrastructure is not suitable for this volume of traffic, which can lead to traffic accidents and injuries to drivers and passengers (15).

Yazd, located in the center of Iran, is one of the provinces with a high number of motorcycle accidents. Motorcycles are the most common means of transportation in this city, which has increased the number of injuries caused by these vehicles. This vehicle is used by a wide range of people of different ages. Therefore, injuries caused by them affect almost all age groups (16).

The northern provinces have become one of the main places with many pedestrian injuries in Iran due to the high population density and the proximity of residences to tourist roads (17). The rural roads in this geographical area are not suitable for high traffic volumes, especially during the holiday season, and this has led to accidents involving pedestrians, most of whom are locals. The southeast of Iran has also become another geographical region where numerous incidents occur due to the lack of suitable hiking trails

6. Conclusion

From the results of this study, it is clear that each of the four types of road traffic accidents occurs among all age groups, genders and in certain geographical areas for different reasons. The best message that can be drawn from these results is that different plans are needed to prevent and control each of these injuries; besides advertising and training necessary safety actions such as wearing helmets, creating specific tracks or paths for cycling are the best measures to control cyclist injuries. Establishing proper roadways in tourist and transit areas can also help reduce motor vehicle and pedestrian accidents. Finally, educating children and rehabilitating the elderly may also be appropriate measures to control and reduce pedestrian injuries.

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Footnotes

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Ethical statement: We used the open access data that available from the Institute for Health Metrics and Evaluation (IHME).
Consent for publication: Not applicable.
Conflict of interest statement
Abbreviations: WHO: World Health Organization; EMRO: Eastern Mediterranean Regional Office; GBD: Global Burden of Disease; RTIs: Road Traffic Injuries
Authors' contributions: All authors participated in this study; MTS is the principal investigator and the main author who supervised the process of study. MTS, SMT and AK analyzed the data and wrote the final draft of the manuscript. SMT and SJM revised the manuscript and finally approved the manuscript before submission. The authors read and approved the final manuscript.

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