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High crash areas resulting in injuries and deaths in Tehran traffic areas from november 2011 through february 2012: a geographic information system analysis

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Abstract

Background: Evaluation of intra-city roads in terms of environmental factors of motor vehicle injuries can help us to better identify these factors and the share of each of the factors in injuries. Therefore, this study was conducted to determine the high injury areas and the risk factors of motor vehicle crashes resulting in injury and death in Tehran, the capital city of Iran, from November 2011 through February 2012.

Methods: In this cross sectional study, the locations of the motor vehicle injuries resulting in injuries and deaths were obtained from police stations in Tehran. The coordinates of the injuries locations were extracted and entered into the Arc-GIS software to overlay the different layers of geographical data and extract the risk map.

Results: A total of 4257 motor vehicle injuries were evaluated in this study. Forty-two injuries (1%) resulted in death and 4215 injuries (99%) resulted in injury. The traffic districts 5 and 21 had the highest frequency of injuries resulting in death. The type of the motor vehicle resulting in injury or death was motorcycle in 2330 injuries (54.73%).

Conclusion: The frequency of traffic injuries is more in the west and northwest areas of Tehran, and it is caused more by motorcycles in terms of traffic and motor injuries resulting in injury and death. It is useful to conduct more studies to better identify these factors considering their importance in traffic injuries.

Keywords: Injuries, Traffic, Geographic Information Systems, Motor Vehicles, Iran.

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Introduction

Traffic injuries are the main cause of death and disability that result in 1.2 million fatalities and tens of millions injury per year worldwide (1). World Health Organization (WHO) designed "Safe Roads" as the theme of the World Health Day 2004 and addressed the decrease in road injuries by 2020 (2). Considering the global burden of diseases study, it was estimated that road injuries ranked eighth in the world in 2010 in terms of years of lives lost (3). Based on a WHO report in 2008, the rate of children death due to road injuries showed a considerable difference between African countries, low and middle income European countries and high income European countries. For example, the death rates of road

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injuries in children aged 5-9 years in these countries were 50, 5 and 1.5 in 100,000 populations, respectively (4). Also, the General Assembly of the UN passed a global plan for the decade of action (2011-2020) for road safety and requested all members to take steps to lower road injuries (5). Based on a WHO report in 2013, in middle and low income countries, adolescents and young adults (15-30 years) had the highest proportion of death (more than 30%) due to road injuries (6).

According to the national study of the burden of disease and injury in Iran, road injuries ranked first in terms of lost years of lives due to premature death (7). Considering a recent study of the mortality profile in Iran, traffic related injuries were the cause of 24.47% of the deaths during 2003-2007, and the mean age of the victims was 37 years (8). Based on a report from the Iranian Legal Medicine Organization in 2011 and 2012, 20,068 and 19,089 deaths and 297,252 and 318,802 injuries occurred due to traffic injuries in Iran, respectively. Moreover, based on the available statistics in the recent seven years, 20,000 to 28,000 people die and 250,000 to 320,000 people are injured in traffic injuries each year in Iran (9).

Many studies have addressed the role of the environmental factors in road and traffic injuries worldwide. A study in the US reported that with the start of the summer, the proportion of the pedestrian deaths to total deaths decreased by 13% between 5-10 o'clock in the morning and 4-9 o'clock in the evening, and motor vehicle fatalities reduced by 3% during the same time periods (10). A study in England showed that visibility aids improved the drivers' recognition and detection. During the day, fluorescent materials in yellow, red and orange colors enhanced the drivers' recognition and detection, which could improve the safety of the pedestrians and cyclists (11). A study in Sweden showed that when the streets were crowded and the traffic was the heaviest, the safety of the pedestrians increased compared to other times (12). According to a study in Canada, pedestrians, cyclists and motor vehicle passengers were significantly more injured in the poor than in the rich areas, mainly due to geometric errors in the road design and heavier traffic in the poorer areas (13). Recognition and correction of the environmental factors can play a very important role in controlling traffic injuries. For example, Denmark and Germany had been successful in making effective policies and environmental changes to reduce pedestrian injuries (14). Spatial analyses in Chile showed that the occurrence of road injuries in young adult pedestrians was significantly associated with the time of day, straight road sections and intersections and lack of traffic signs on the roads. (15). In Costa Rica, a combination model of regression models and geographic information systems were used to estimate the frequency of traffic injuries in 83 separate administrative and geographic districts. The results showed that multivariate spatial models performed better than their conventional and univariate counterparts in terms of goodness of fit and accuracy of estimating additional hazards (16).

In Iran, due to the increased rate of car production, road traffic has significantly increased in intercity and intra-city roads while the roads have not been developed accordingly. Many road injuries in Iran occur as a result of environmental factors, especially the quality of roads and streets. Evaluation of intercity and intra-city roads in densely populated cities with heavy traffic like Tehran helps to better identify the environmental factors of injuries and determine the role of each of these factors. The results of such evaluations can be used to design programs to decrease the risk factors. Therefore, this study was conducted to determine the high injury areas and the risk factors of motor vehicle injuries resulting in injury and death in Tehran from November 2011 to February 2012.

Methods

Data

This study was designed as a cross-

sectional descriptive analytic research. In this study, the target population was the traffic injuries resulting in injury or death in Tehran in 2011-2012. Using the statistics of intercity and intra-city road injuries in all provinces provided by the traffic Police of Iran, the weekly number of the injuries was calculated to be 300 in Tehran in 2010. Since the above-mentioned variable followed the Poisson distribution, its standard deviation could be 17.3. Therefore, through the evaluation of 12 consecutive months, the standard error of mean injuries was estimated to be 5. Hence, with 95% confidence interval, the mean number of weekly injuries was estimated to be 295-305. We expected to observe the difference in the number of weekly injuries if it was more than 3%. The difference between various months could be similarly evaluated. Consequently, the estimated number of injuries for evaluation was 3660 in this study. Therefore, the injuries occurring from November 2011 to February 2012 (more than 4200 injuries) were analyzed. The locations of the injuries were provided by the Traffic Police stations. Their coordinates were determined using a map of Tehran and entered into the Arc-GIS software.

Statistical Analysis

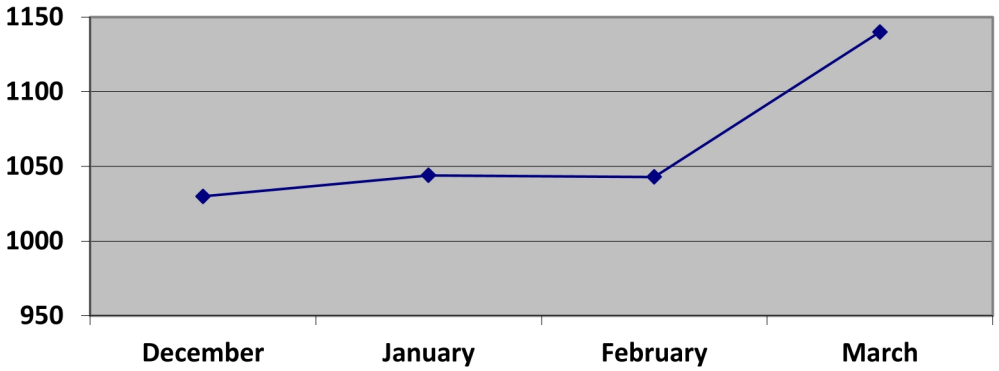
Descriptive and analytical analyses were performed on the data. In descriptive analysis, mean and standard deviation (SD) were used for quantitative variables, and absolute and relative frequencies were used for ordinal and categorical variables. For analytical analyses, chi square, and the OR index and confidence interval (if necessary), were used to evaluate the relationship between the quantitative variables. For drawing the maps, the Arc-GIS software was used to overlay the different layers of geographical data and extract the risk map of the streets and highways of Tehran, which showed the high injury locations.

Results

A total of 4257 injuries were evaluated in this study. Forty -two (1%) injuries resulted in death and 4215 (99%) resulted in injury. In our study, 4037 (94.8%) of the offending

Table 1. The relationship between the severity of traffic injries in Tehran and environmental factors

Variable	Variable levels	Death		Injury		Total		p	OR	95% CI OR
		n	*%*	*n*	*%*	*n*	*%*			
Gender of the offending driver	female	6	2/7	214	97/3	220	100	0/02	3/11	، 7/74 1/29
	male	36	0/9	4001	99/1	4037	100			
Age of the offending driver	above 40 years	12	1/3	945	98/7	957	100	0/34	1/38	، 2/71 0/70
	below 40 years	30	0/9	3270	99/1	3300	100			
Hour	12 am-12 pm	16	1/2	1356	98/5	1372	100	0/41	1/29	، 2/72 0/80
	12 pm-12 am	26	0/9	2859	99/1	2885	100			
Daylight	night	20	1/2	1604	98/8	1624	100	0/20	1/48	، 2/72 0/80
	day	22	0/8	2611	99/2	2633	100			
Day of the week	Saturday	7	1/2	578	98/8	585	100	0/89		
	Sunday	5	0/8	641	99/2	646	100			
	Monday	5	0/8	618	99/2	623	100			
	Tuesday	6	1/0	614	99/0	620	100			
	Wednesday	5	0/8	622	99/2	627	100			
	Thursday	9	1/4	620	98/6	629	100			
	Friday	5	0/9	522	99/1	527	100			
Type of the injury location	non residential	19	1/4	1301	98/6	1320	100	0/04	1/84	، 3/40 1/00
	residential	23	0/8	2908	99/2	2931	100			
Road surface	wet and slippery	4	1/2	270	98/8	274	100	0/52	1/53	، 4/33 0/54
	dry	38	1/0	3939	99/0	3977	100			
Weather condition	unstable	4	1/1	384	91/9	384	100	0/54	1/04	، 2/95 0/37
	clear	38	1/0	3825	99/0	3863	100			
Type of the vehicle	car	24	1/2	1903	98/8	1927	100	0/11	1/63	، 3/01 0/88
	motorcycle	18	0/8	2312	99/2	2330	100			
Mechanism of injury	pedestrian-motor vehicle injury	20	2/1	950	97/9	970	100	*<0.001*	3/12	، 5/74 1/69
	car-motorcycle injury	22	0/7	3265	99/3	3287	100			

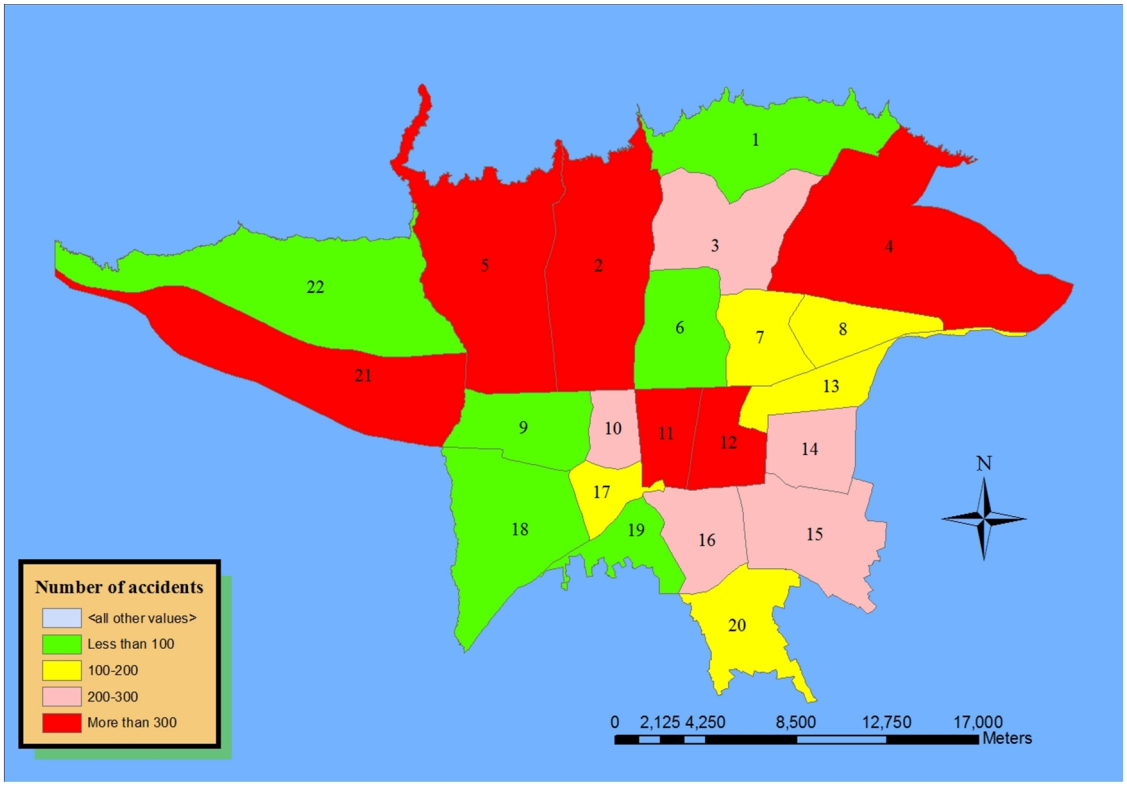


Graph 1. The Trend of the evaluated injries based on month

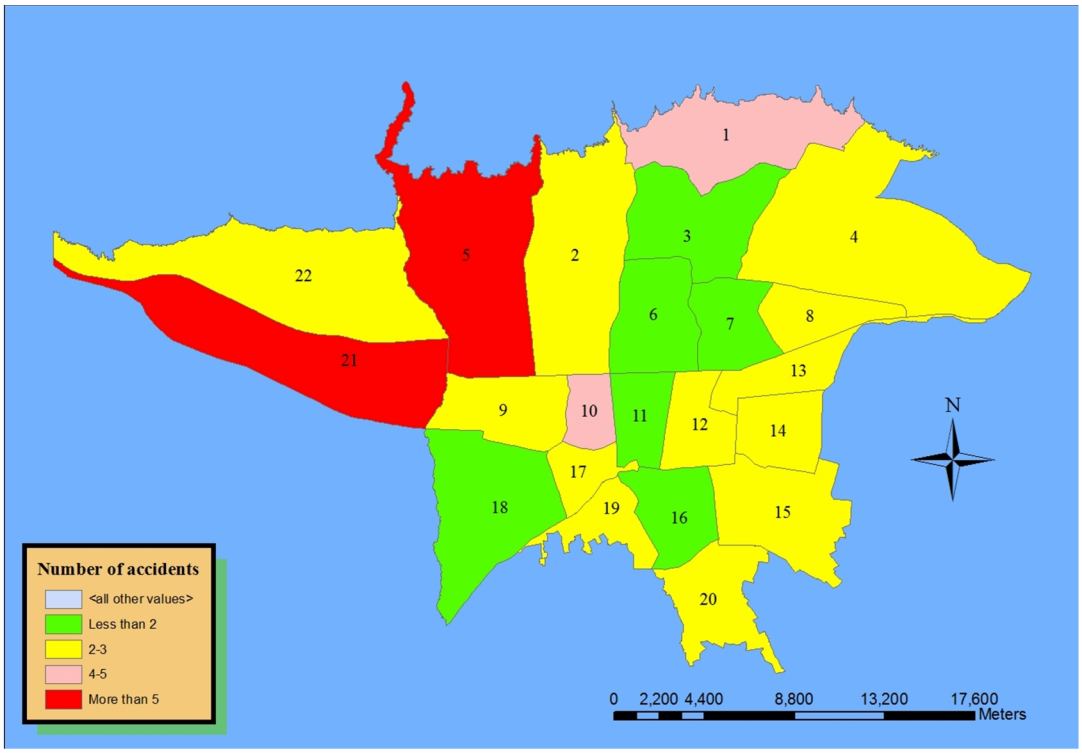
drivers were men and 220 (5.2%) were women. The mean±SD age of the offenders was 32.64±11.28 years.

Table 1 demonstrates the relationship between the severity of the traffic injuries and different human and environmental factors. Traffic injuries resulting in death or injury were more in female drivers aged above 40 years, time between 12 am and 12 pm, nights, Thursdays, non-residential areas, slippery and wet roads, unstable weather, automobile related injuries, pedestrian-motor vehicle injuries and injuries which occurred due to environmental or motor vehicle factors. Evaluation of the above-mentioned factors with the severity of the traffic injury showed a significant association with the driver's sex, function of the injury location, and the mechanism of the injury. The level of significance and OR (if necessary) of the variables are summarized in Table 1. The type of motor vehicle causing death or injury was the motorcycle in 2330 (54.73%) of injuries.

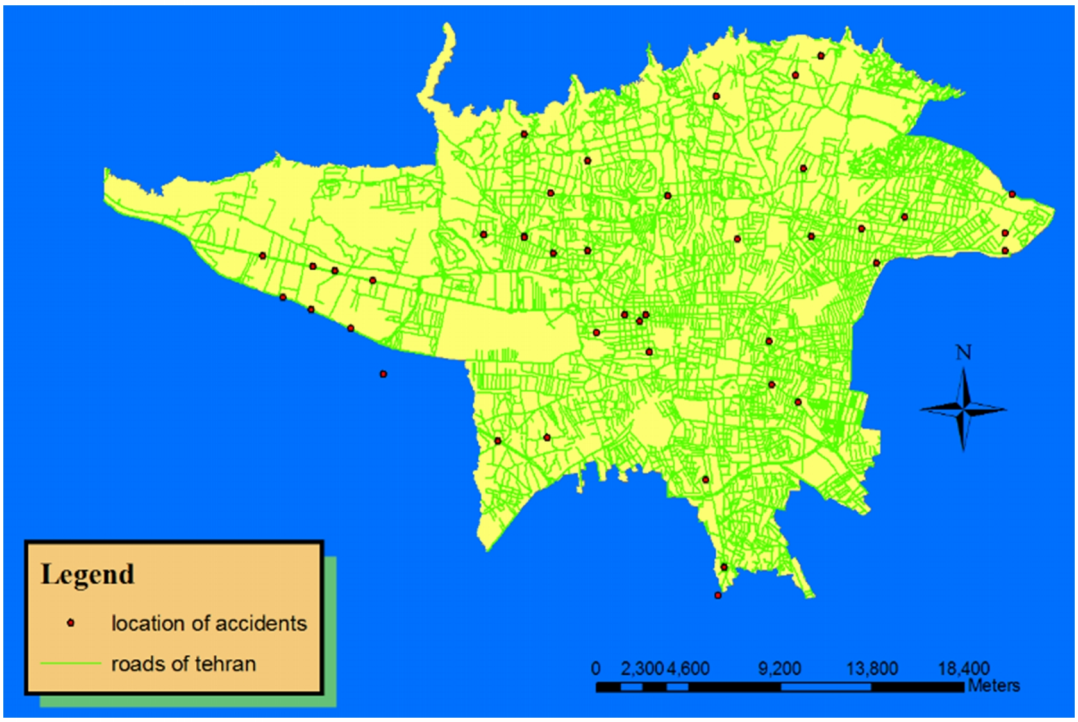
Hemmat Highway with 73 (1.71%) injuries, Karaj Special Road with 64 (1.5%)



Map 1. The frequency of injury injries in Tehran traffic areas from November 2011 through February 2012 (each area number is located within the map).



Map 2. The frequency of fatal injries in Tehran traffic areas from November 2011 through February 2012 (each area number is located within the map).



Map 3. Distribution of fatal traffic injries in Tehrans street

injuries and Azadegan Highway with 63 (1.48%) injuries comprised the high injury locations of Tehran.

The injuries were more in the last month of the Iranian calendar (the month leading to the Iranian New Year) versus the previous three months. Graph 1 shows the trend of the evaluated injuries based on the month in which they occurred. Map 1 shows that traffic districts of 2, 4, 5, 11, 12, and 21 had the highest frequency, and the traffic districts of 1, 6, 9, 18, 19, and 22 had

the lowest frequency of traffic injuries causing injury in the study period. Map 2 demonstrates that traffic districts of 5 and 21 had the highest frequency and the traffic districts of 3, 6, 7, 11, 16 and 18 had the lowest frequency of traffic injuries causing death in the study period. Map 3 displays the frequency distribution of the injuries causing death.

Discussion

Map 2 illustrates that traffic districts of 5 and 21 had the highest frequency of traffic injuries causing death in Tehran. On the other hand, Map 1 suggests that these two districts are among the districts with the highest frequency of traffic injuries causing injury in Tehran. Moreover, Hemmat Highway, Karaj Special Road, and Azadegan Highway which are high injury locations are mainly located in the west and northwest of Tehran. According to the municipality districts map of Tehran, three municipality districts of 5, 21 and 22 are located in the west and northwest of Tehran. Since the district 22 is the newest municipality district which was added to Tehran in 2000, and it is not mainly a residential now, it can be concluded that the west and northwest of Tehran have more traffic injuries.

Our study showed that the frequency distribution of traffic injuries causing injury and death in the city of Tehran was different based on different variables during the study period. These variables could be categorized into 3 categories including driver variables, environment variables and vehicle variables. Most of the injuries were caused by men and middle aged individuals. The main reason may be that the majority of the drivers in Tehran are middle-aged men. However, analysis of the severity of injuries showed that 6 (2.7%) out of 220 injured women and 36 (0.9%) out of 4037 injured men died (p= 0.02); therefore, the severity of the injuries caused by women was significantly more than men.

Although the severity of the injuries caused by drivers who were younger than 40 years of age was less than other drivers, the difference was not significant. This is against the finding of some other studies including studies conducted by Harrison et al. in Australia (17), Romano et al. in the USA (18) and Vassalo et al. in Australia (19) who reported that younger drivers played a major role in severe traffic injuries. On the other hand, many studies including those performed by Lawrence in Australia (20), Bianchi, Alessandra and colleagues in Finland (21) and Boyce et al. in the US (22) have shown that younger drivers do not observe the speed limit, which is one of the most important risk factors of traffic injuries. Hence, one of the reasons for the low severity of traffic injuries in drivers aged less than 40 in Tehran might be due to the fact that the traffic is heavy in most of the streets and highways and that the young drivers do not get a chance to over speed because of the speed cameras in highways.

Our study showed that 68.9% of the traffic injuries occurred in residential areas. Furthermore, 19 (1.4%) out of 1320 injured individuals in non-residential areas and 23 (0.8%) out of 2931 injured persons in residential areas died (P=0.04). These results indicate that the severity of traffic injuries is more in non-residential areas than in the residential areas. Therefore, it is essential to explore the reasons of this finding through more studies and devise appropriate preventive measures.

The results revealed that the frequency of traffic injuries was higher from 12 am to 12 pm (67%). However, the severity analysis showed that the occurrence of the injuries resulting in death was more between 12 pm and 12 am, especially in the early morning, while the lowest proportion of the injuries causing death occurred between 12 am and 6 pm although the difference was not significant. Studies conducted by Lam in Australia (23), Romano et al. in the USA (18), and Rivara and Barber in the USA (24) have also shown that the time of the day and daylight are associated with the occurrence and severity of the traffic injuries.

They also have reported that the odds of severe traffic injuries are more at night than the day.

Our study also showed that slippery roads caused more severe injuries than non-slippery roads; as a result, the proportion of the injuries causing death was higher in slippery roads although the difference was not significant. A number of other studies have reported similar findings. A study conducted by Karlaftis et al. in Greece showed that the quality status of the road surface and its slipperiness were significantly associated with the occurrence of traffic injuries in two-lane and single-lane roads (25). Therefore, improving the quality of the road surface and rapid snow removal from the streets to prevent icy roads can lower the number and severity of the injuries in Tehran.

Our study showed that more injuries occurred in unstable weather although the difference was not significant. A study conducted by Hijar et al. showed that travelling under adverse weather conditions was one of the most important risk factors of traffic injuries in highways in Mexico (26).

Twenty (2.1%) out of 970 injured people involved in pedestrian-vehicle injuries and 22 (0.7%) out of 3287 injured persons involved in car-motorcycle injury deaths ($P<0.001$). Based on the results, although the severity of the car-motorcycle injuries was less than pedestrian-motor vehicle injuries, cyclists were the cause of 55% of the evaluated injuries; therefore, cyclists are the most important cause of injuries in Tehran. Previous studies in Tehran have shown that cyclists comprise a major proportion of traffic injury victims. For example, a study by Montazeri et al. in 2000 showed that 12% of the traffic injury victims in Tehran were cyclists (27). Many factors are important in this regard among which low traffic culture, mass production and use of motorcycles in the country and poor implementation of the related rules and regulations can be named. However, in the recent years, increasing the fines for driving offences and more strict punishment of the offending drivers and cyclists have resulted in better obedience of the traffic rules by cyclists. According to a study by Roudsari et al. in 2004, only 6% of the cyclists used a helmet (28) while its use has increased significantly recently. A study by Younesian et al. in Tehran showed that although the project of organizing cyclists by the police did not decrease motorcycle related traffic injuries, it decreased severe injuries and trauma to the head and face (29). Graph 1 demonstrates that traffic injuries occurred more in the final month of the Iranian calendar leading to the Iranian New Year which could be due to the increased transportation for shopping and preparing for the New Year. This matter needs further attention and the injuries in this month need to be compared with all other months of the year in future studies.

Our study had some limitations. In Iran, the time between death and traffic injury is not defined. Therefore, the traffic police data was used for our project.

We included only the injuries that occurred in the final four months of the Iranian Calendar (from November to February 2012). As a result, we could not evaluate the monthly and seasonal trend of the injuries in the entire year.

Conclusion

This is one of the few studies to evaluate the risk factors of traffic injuries in intercity and intra-city roads of Iran with the use of a geographic information system. Based on our findings, the frequency of the traffic injuries is more in the west and northwest areas of Tehran and the motorcycles are the main vehicles resulting in injury and death. Moreover, the severity of the traffic injuries is more in women, non-residential areas and pedestrian-motor vehicle injuries. These factors need to receive more attention, and practical steps should be taken to design better preventive plans to lower traffic injuries and enhance the safety of the roads. More studies are required to evaluate the factors that were not addressed in this study.

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