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Temporal Patterns of Road Traffic Injuries in Iran

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Abstract

Background: Road traffic injuries (RTIs) are the main causes of death and disability in Iran. However, very few studies about the temporal variations of RTIs have been published to date.
Objectives: This study was conducted to investigate the temporal pattern of RTIs in Iran in 2012.
Materials and Methods: All road traffic accidents (RTAs) reported to traffic police during a one-year period (March 21, 2012 through March 21, 2013) were investigated after obtaining permission from the law enforcement force of the Islamic Republic of Iran. Distributions of RTAs were obtained for season, month, week, and hour scales, and for long holidays (more than one day) and the day prior to long holidays (DPLH). The final analysis was carried out using the Poisson regression model to calculate incidence rate ratios for RTIs. All analyses were conducted using STATA 13.1 and Excel software; statistical significance was set at $P < 0.05$.
Results: A total of 452,192 RTAs were examined. The estimated rate of all accidents was 219 per 10,000 registered vehicles, or 595 per 100,000 people. About 28% of all RTAs, and more than one third of fatal RTAs, occurred during the summer months. The incidence rate for all traffic accidents on DPLH was 1.20, compared to workdays as a reference category, and it was 1.40 for fatal crashes. The rate of fatal road traffic accidents in outer cities was 3.2 times higher than in inner ones.
Conclusions: Our findings reveal that there are temporal variations in traffic accidents, and long holidays significantly influence accident rates. Traffic injuries have different patterns on outer/inner city roads, based on weekday and holiday status. Thus, these findings could be used to create effective initiatives aimed at traffic management.

Keywords: Temporal Pattern, Road Traffic Injury, Iran

1. Background

Road traffic injuries (RTIs) remain a global public health problem and are anticipated to be the fifth-leading cause of mortality around the world through the year 2030 (1, 2). RTIs also exert a significant impact on the affected families, health care services, and national economies (3-5). Traffic injuries, with an annual occurrence rate of 26.5 cases per 100,000 people, are the second-leading cause of mortality and leading cause of disability adjusted life years (DALY) in Iran (6, 7). In order to minimize the number of RTIs, identifying the factors that influence road crashes is the main purpose of traffic safety programs. There are many different types of studies regarding the seasonality effect of traffic accidents. Keay, working in Melbourne metropolitan area of Australia, showed that traffic volume was affected by weather situations in the winter and spring. A reduction in traffic volume was observed on wet days (8). Sukhai's findings in South Africa showed that some factors, such as alcohol and school holidays, could be significant predictors of weekly RTIs (9). Karacasu's study showed that traffic changes are related to the time of day, and the maximum level was observed between 7:00 and 9:00 A.M., and then surged again between 5:00 and 7:00 P.M. (10). Other studies have shown that the highest number of RTIs is observed in summer months, in contrast with other seasons (11-13), and they present some explanations for this, such as: people falling asleep while driving; the lengths of the days; good weather conditions, which allows for more use of motor vehicles; and increasing speed. Comparing RTI rates on holidays with weekdays showed that traffic collisions during holiday periods are, apparently, on the rise (14).

A lack of any information about temporal patterns of road traffic injuries in Iran and the limited number of studies in the literature that have investigated the temporal patterns of traffic injuries and, on the other hand, variations in RTI distribution in terms of time-based scales indicates that it would be reasonable to consider temporal patterns for any interventional programs. Such information could be helpful for making critical decisions regard-

ing when and how traffic management plans should be implemented.

2. Objectives

This study was conducted to determine the situation of RTIs in Iran by examining the temporal patterns of road traffic accidents (RTAs) and to identify any concentrations of and specific trends in traffic accidents over time. It also investigated the fluctuation of traffic crashes based on various temporal scales.

3. Materials and Methods

This cross-sectional study examined all RTAs reported to the police during a one-year period (March 21, 2012 to March 21, 2013). The police collected all Iranian RTI data at accident sites using a computerized registration system based on COM 114, a standardized data collection form that was developed after several successive steps. The form includes data on the crash site, human- and vehicle-related factors, and victim(s). A specific piece of software, called country accident data processing (CADP), was developed for data merging and data processing. After four versions, this program was potentiated and compatible for use by other statistical software package for processing. Accident types were determined as follows: a traffic accident with no injury, which is considered property damage; an accident with at least one injured person, defined as an injury accident; and, if at least one person died as a result of the traffic accident, it was defines as a fatal accident. The rates of RTAs and RTIs were calculated based on Iran's national census in 2011 and police datasets for registered vehicles. Quarterly, monthly, daily, and hourly distributions of RTIs were presented, and the annual rate was calculated to help describe the impact of RTIs in Iran. We used the number of traffic accidents and human-related outcomes (deaths and injuries) as our numerator, and the population diagram and number of registered vehicles as our denominator.

In order to make meaningful and realistic comparisons between holidays and weekdays, we restructured the daily distribution of RTIs as follows: first, we determined long holidays (L-holidays) and the day prior to long holidays (DPLH) during the year as two. Other days, Thursdays, Fridays, and workdays (non-holidays), were three additional categories, respectively, considering all working days as reference. In our study, a "long holiday" refers to a holiday with more than one day. Based on these new categories, we were able to obtain the average corresponding frequencies of RTAs and RTIs.

To compare RTI risks between outer and inner city roads, and DPLH with weekdays, the incidence rate ratio of road traffic accidents with a 95% CI were estimated by fitting Poisson regression models. In these models, the dependent variable was the number of road traffic crashes; the number of days was used as the exposure. The type of day (holiday, weekday, DPLH, Fridays) and location of accident (inner, outer city roads) were considered the explanatory variables. In this study, a road traffic accident refers to an accident that involves at least one vehicle. Because of missing data for some crashes, total rates were slightly varied from those calculated for time scales. The data was analyzed using STATA 13.1 and Excel software; statistical significance was set at $P < 0.05$.

4. Results

In 2012, the total population of Iran was 76 million, and the number of registered vehicles in 2010 was 20.6 million (15, 16). Overall, 452,192 road traffic crashes were recorded in the police data capture system. The estimated rate of total RTAs was 219 per 10,000 registered vehicles, which equals 595 crashes per 100,000 people.

A total of 11,087 people lost their lives, and 234,239 were injured. The fatality and injury rates were estimated at 5 and 113 per 10,000 registered vehicles, which is equal to 15 and 308 per 100,000 people, respectively. Among crashes whose types were identified, 426,730 in all, more than 2% were fatal, and about 48% resulted in an injury (Table 1).

Table 1. Rates of Road Traffic Injuries Based on Type of Accident and Casualty

	Frequency, %	Per 10,000 vehicles	Per 100,000 people
Type of accident			
Property damage	211,447 (49.6)	102	278
Injury	205,436 (48.1)	99	290
Fatal	9847 (2.3)	4.8	13
Total Crashes	426,730 (100.0)	219	595
Casualties			
Injured	234,239 (95.4)	113	308
Dead	11,087 (4.6)	5	15
Subtotal	245,326 (100.0)	119	323

4.1. Hour of Road Traffic Accidents

Figure 1A shows the hourly distribution of RTAs. The majority of RTAs occurred between 6 and 8 A.M. (15%), followed by crashes between noon and 2 P.M. (13%), and those occurring between 10 P.M. and midnight (12.2%). Only a minority of crashes happened between 2 and 6 A.M. (3.11%).

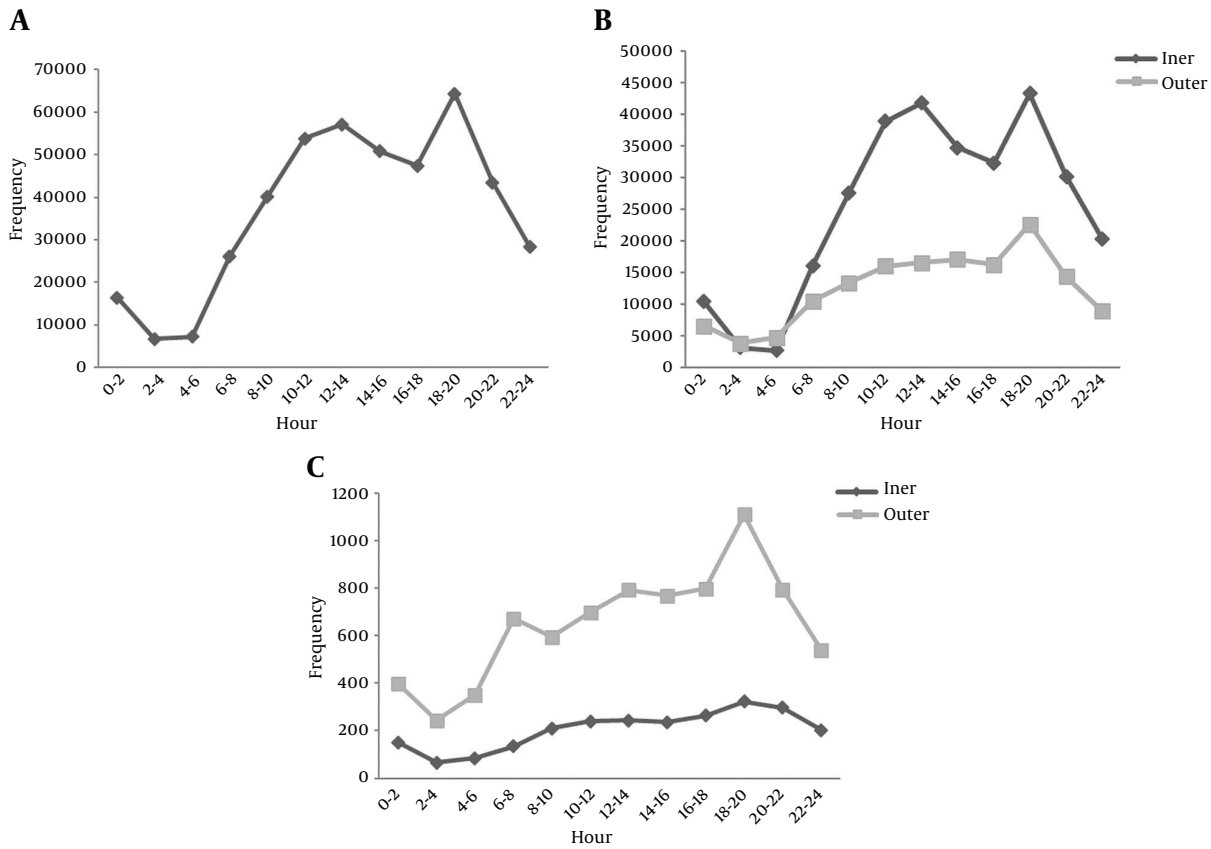

Figure 1. A, Hourly distribution of all RTAs; B, distributions of inner and outer RTAs, by hour; C, distributions of fatal RTAs, by hour, in inner and outer areas.

Figure 1B shows the different patterns of all RTAs, by hour, for both inner and outer city roads throughout the day. While the frequency of RTAs for inner city roads was low in the early morning, it appears to increasing between 6 A.M. and 8 P.M. However, Figure 1C indicated, the number of fatal crashes was much higher on outer roads, compared to inner roads, with two peaks occurring daily, between 6and 8 A.M. and again between 6 and 8 P.M.

4.2. Day of Road Traffic Accidents

Figure 2A shows the weekly distributions for all types of RTAs. There are similar patterns, with a small decrease on Fridays and a slight increase on Thursdays. It should be noted that Thursdays and Fridays are the weekends in Iran. On the other hand, Figure 2B shows the modified number of RTAs for new categorizations of weekdays, with a peak on DPLHs and the minimum on Fridays. The frequencies in the new restriction varied significantly (Table 2). Compared to workdays (as a reference), DPLHs had the highest incidence rate ratio (IRR), 1.20 (95% CI: 1.18 - 1.22), for all types of accidents. In fatal crashes, the IRR for DPLHs and L-holidays were 1.40 (95%CI: 1.28 - 1.52) and 1.13 (95% CI: 1.05 - 1.21), respectively. The calculated IRRs on Fridays and Thursdays for all accidents were, accordingly, 0.96 (95% CI: 0.90 - 1.01) and 0.97 (95% CI: 0.91 - 1.02) (Table 3).

4.3. Months and Seasons of Road Traffic Accidents

As Table 2 shows, there were marked increases in RTAs in August and June. The rate of fatal crashes reached 1.5 per 100,000 people in August, which was the highest rate for any month. The lowest rate for RTAs was observed in December, with 0.7, or 18.4 per 100,000 people, for fatal and injury crashes, respectively.

Summer and winter had the highest and lowest rates, respectively, for all types of RTAs (Table 2). Figure 2D also shows the seasonal pattern for sub types of RTAs: 31% of fatal accidents and 29.6% of injury accidents occurred during the summer, while these measures for winter were 19.2% and 20.7%, respectively.

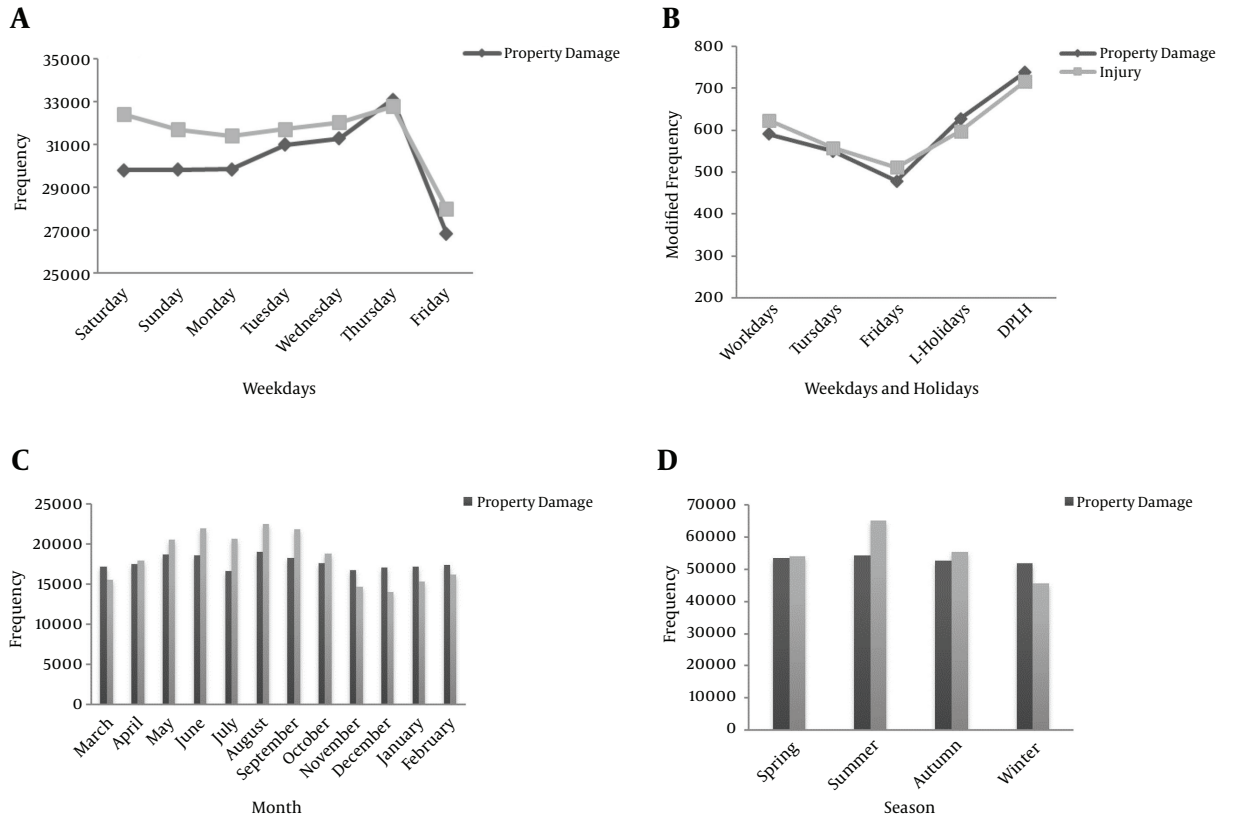

Figure 2. A, Weekly distribution of RTAs; B, modified number of RTAs on weekdays; C, monthly numbers of RTAs; D, seasonal numbers of RTAs for inner and outer city roads.

4.4. Location of Road Traffic Accidents

This study revealed some noteworthy findings regarding location of RTIs. The predominant proportion of RTAs (more than 65 %) occurred on inner city roads. Although the majority of property damage and injury accidents (63% and 73%, respectively) occurred on inner city roads, 76% of fatal accidents were observed on outer city roadways. Specially, the fatal accident rate on DPHDs was three times greater for outer roads compared to inner ones (Table 3).

5. Discussion

The majority of RTAs occurred between 6 and 8 P.M., and the fewest were observed between 2 and 6 A.M. The number of fatal crashes was noticeable higher on outer roads, compared to inner roads, with two peaks: between 6 and 8.00 A.M. and again between 6 and 8 P.M. A significant peak of RTAs was observed on DPLHs, and the fewest occurred on Fridays. DPLHs and L-holidays had the highest incidence rate ratio of RTAs, and the lowest IRR was observed on Fridays and Thursdays, the Iranian weekend.

There was a significant variation in the total number of RTAs in August and June. Summer and winter, respectively, had the highest and lowest rates of all RTAs. The predominant proportion of RTAs occurred on the inner city roads. Although the majority of property damage and injury accidents occurred on inner city roads, the fatal accident rate on DPHDs was three times greater for outer roads, compared to inner ones. Karacasu's study showed that traffic changes are related to the time of day, and the maximum level was observed between 7 and 9A.M., and surged again between 5 and 7 P.M. (10). Typical workdays in Iran begin one hour earlier than in other countries; this explains the different time surges found in our study.

Our results showed similar patterns for traffic accidents on weekdays, with only a small decrease on Fridays. We again reset the weekdays based on holidays and weekdays; however, modified values for traffic accidents showed that the frequency of all types of accidents on DPLHs was significantly higher than on other days. For example, the estimated risk for a fatal accident was 40% greater on a DPLH than on a workday. Given that Friday is part of the weekend in Iran, the measures for incidence

Table 2. Distribution of Road Traffic Accidents Based on Temporal Scales (Monthly, Seasonally, and Weekly)

	Accident Type (Rate[a])		
	Property Damage	Injury	Fatal
Monthly			
March	17,151 (22.6)	15,584 (20.5)	932 (1.2)
April	17,453 (23.0)	17,974 (23.7)	854 (1.1)
May	18,720 (24.6)	20,519 (27.0)	948 (1.2)
June	18,544 (24.4)	21,898 (28.8)	1081 (1.4)
July	16,664 (21.9)	20,662 (27.2)	955 (1.3)
August	18,998 (25.0)	22,525 (29.6)	1122 (1.5)
September	18,231 (24.0)	21,873 (28.8)	948 (1.2)
October	17,648 (23.2)	18,850 (24.8)	827 (1.1)
November	16,704 (22.0)	14,716 (19.4)	581 (0.8)
December	17,103 (22.5)	14,019 (18.4)	566 (0.7)
January	17,187 (22.6)	15,368 (20.2)	708 (0.9)
February	17,424 (22.9)	16,181 (21.3)	681 (0.9)
Seasonal			
Spring	53,324 (70.2)	54,077 (71.2)	2734 (3.6)
Summer	54,206 (71.3)	65,085 (85.6)	3158 (4.2)
Autumn	52,583 (69.2)	55,439 (72.9)	2356 (3.1)
Winter	51,714 (68.0)	45,568 (60.0)	1955 (2.6)
Weekly			
Saturday	29,827 (39.2)	32,416 (42.7)	1432 (1.9)
Sunday	29,838 (39.3)	31,716 (41.7)	1413 (1.9)
Monday	29,858 (39.3)	31,426 (41.4)	1358 (1.8)
Tuesday	31,018 (40.8)	31,728 (41.7)	1408 (1.9)
Wednesday	31,306 (41.2)	32,043 (42.2)	1536 (2.0)
Thursday	33,120 (43.6)	32,805 (43.2)	1635 (2.2)
Friday	26,860 (35.3)	28,035 (36.9)	1421 (1.9)
Weekdays and holidays status[b]			
Work days	1269	624	27
Thursdays	1158	557	27
Fridays	1045	512	26
Long holidays	1287	598	31
Days prior to long holidays	1524	716	38

[a] Per 100,000 population.
[b] Average number of RTAs.

rate ratios for "L-holidays" and DPLH were higher than those for "Friday" and "Thursdays." Holidays substantially are associated with variability in traffic volumes and, consequently, an increased risk of vehicle crashes (17). Furthermore, other studies have shown that risky driving behaviors, such as alcohol consumption (14, 18, 19), are more frequent in holidays. The studies also revealed that vehicle occupancy increases on holidays; therefore, the probability of injuries to occupants is increased, due to increased exposure (20). However, our results showed that the modified number of accidents appears to occur more often on DPLH than on other workdays. This may be because many people begin their travels on the day before holidays.

The study results revealed differences in the seasonality patterns of traffic accidents. The distribution of accidents by month had little variation, with the most in August and June, and the fewest in June. The number of collisions appears to be highest in the summer and lowest in the winter. This is consistent with the results of other studies (13, 21). Variations in traffic accidents are likely attributed to many factors, and the main factor is probably the different traveling patterns throughout the year. Variations' lengths are longer and more people take their annual vacation during the summer, and these may be considered as the main related factors to the increased accident rate during the summer season. Other studies have suggested other explanations, such as falling sleep, long drives, and alcohol consumption as the reason for the summer peak in RTIs (11).

The study showed that the distribution of RTAs varies according to location. In contrast with inner city roads, the risk of having a fatal accident was significantly greater in the outer city, especially on DPLH. However, property damage and injury accidents were more frequently observed on inner city roads. Results from other studies have also shown a high percentage of fatalities in rural versus urban areas (21, 22). One study, however, showed that 75% of RTIs occurred on Iran's city streets (23). This finding may be rooted in the fact that driving on outer roads is also often associated with some risky behaviors, such as high-speed driving.

The eastern mediterranean region (EMR) has the second-highest road traffic fatality rate in the world (24), and Iran has a high frequency rate of RTIs among the EMR countries (25, 26). Our study revealed that more than half of all of road traffic crashes in Iran were accompanied by fatal and non-fatal injuries. Our study has estimated the traffic mortality rate in Iran is 15 per 100,000 people. Based on a world health organization study, and as noted above, the estimated RTI mortality rate for the EMR is higher than our estimation (27). This underestimation is a result of the limited nature of police data related to accident sites and to data that is missing from the statistics, such as information about fatalities occurring during a patient's transfer to an emergency department of after discharge from the

Table 3. Incidence Rate Ratios of Accident Types, Based on a Categorized Scale

Accident Type	Weekday and Holiday Status[a]				Location Outer vs. Inner City Roads
	Thursdays	Fridays	Long Holidays	Day Prior to Holidays	
Fatal					
Incidence Rate Ratio (IRR)	0.97	0.96	1.13[b]	1.4[b]	0.59[b]
95% CI	0.91 - 1.02	0.90 - 1.01	1.05 - 1.21	1.28 - 1.52	0.58 - 0.60
Injury					
IRR	0.89b	0.82[b]	0.96[b]	1.15[b]	3.20[b]
95% CI	0.88 - 0.90	0.81 - 0.83	0.94 - 0.97	1.12 - 1.17	3.01 - 3.30
Property damage					
IRR	0.93[b]	0.81[b]	1.06[b]	1.25[b]	0.36[b]
95% CI	0.92 - 0.94	0.79 - 82	1.04 - 1.08	1.22 - 1.27	0.36 - 0.37

[a]Workdays as Reference.
[b]P < 0.001.

hospital. It is estimated that, among all fatalities, about 60% occur at crash site or en route to healthcare centers, while 30% happen during a hospital stay, and 5% - 10% occur after hospital contact (28).

Our use of the massive datasets available and delineating temporal patterns for the first time in Iran can be considered one of the strengths of this study. On the other hand, this study has suffered from missing values; the way in which we have dealt with this has been mentioned previously. Still, the missing data can be considered a weakness of the study.

In conclusion, this study revealed that there are variations in time scales related to RTIs in Iran. Considering this variability, and aiming to reduce RTIs, new policies should be designed and proper interventions should be implemented.

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Footnote

Authors' Contribution: Ali Khorshidi: Design, study performance, data analysis and writing; Elaheh Ainy: Data analysis and writing; Hamid Soori: Data analysis and writing; Saeed Hashemi Nazari: Design and writing.

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