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Does fasting in Ramadan increase the risk of traffic accidents? A time series analysis

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Abstract

Background Ramadan in the Muslim world has its rituals and customs which can cause more traffic at certain times of the day. Getting stuck in traffic for hours near Iftar decreases blood sugar and can lead to stress, anger, ignoring driving rules and finally traffic accidents.

Method This is a descriptive, analytical, and retrospective study on the data of traffic accidents leading to vehicle damage in addition to occupant injury, and death in Guilan, which was conducted from 2013 to 2016. The data were obtained from two databases of Iran Road Maintenance and Transportation Organization and Meteorological Organization in Guilan province. The trends of traffic accidents before and after Ramadan were compared in three different years using time series (TS) analysis. All analyses were performed with STATA SE v13.1 software. *P*-value less than 0.05 was considered significant.

Results The average daily traffic accidents (*p*-value = 0.040) and injuries (*p*-value = 0.001). increased significantly in the month of Ramadan. The amount of traffic increased significantly. Daily accidents had a significant relationship with the variables of traffic (*p*-value = 0.000), rainfall (*p*-value = 0.000), Ramadan month (*p*-value = 0.000), and holidays (*p*-value = 0.000). Daily injuries was significantly associated with the variables of traffic (*p*-value = 0.000), rainfall (*p*-value = 0.000), Ramadan month (*p*-value = 0.000), and holidays (*p*-value = 0.000). IRR showed that if you consider rainfall, holiday, and traffic, as constant variables then the number of traffic accidents and injuries in Ramadan was higher than that of other months.

Conclusion The responsible organizations in Muslim country are expected to inform the people about increase in traffic accidents and related injuries during Ramadan. Institutions responsible for traffic safety in developing countries like Iran should educate the society to be more attentive about driving behavior in this month. More comprehensive monitoring of traffic and speed control should be performed. Traffic penalties can be a good solution for wrongful drivers to help reduce traffic incidents and injuries.

Keywords Ramadan, Traffic Accident, Emergency, Trauma, Injury

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Introduction

Road traffic accidents (RTAs) have always been a major problem for health systems with the challenge of sharply rising costs of prevention around the world. The annual mortality rate due to RTAs is about 1.35 million, a worrying statistic for healthcare providers [1, 2]. RTAs is the 12th cause of death in the world and the fourth cause of death in Iran, accounting for 4.26% of all deaths here [3].

Most traffic accidents are caused by human factors [4, 5]. Behaviors such as driving in old age due to decreased cognitive abilities and response speed [6, 7], dangerous driving maneuvers [8, 9], drowsiness [10], fatigue [11, 12], high speed [13, 14], and failure to comply with driving regulations [15, 16], the influence of alcohol [17, 18], the use of drugs and psychotropic substances [18, 19], dangerous overtaking; suicide [6, 20], and driving while fasting have also been introduced as patterns leading to accidents in some Muslim countries [21, 22].

In the lunar calendar, Ramadan is the ninth month of the year, which lasts 29 or 30 days. One of the main practices in this month is fasting, in which Muslims must refrain from eating, drinking, and smoking during daylight hours. The purpose of this religious duty is to strengthen patience, spirituality, humility and submission to get closer to God [23].

One of the reasons that can make Ramadan a high-risk month in terms of RTAs is the sunset hours near *Maghreb* call to prayer (Azan) which is a very important moment in this holy month, because it means breaking the fast (Iftar). Sunset in several studies has been considered as the potential time for traffic accidents because of decreasing daylight [24, 25, 26]. During Ramadan, people often come out of home before sunset to do necessary preparations and buy food (bread, etc.) for Iftar or to visit their friends and family (Iftar party). Some may increase speed while driving to reach Iftar on time, so they may break traffic law. Long waiting times in traffic or in stores before sunset may increase stress or anger and lead to driving injuries [27]. In a research, it was reported that in the month of Ramadan, the number of patients admitted to the emergency department decreased, instead, the number of visits one hour after Iftar and one hour before Sahur (Sahur: the meal consumed early in the morning during Ramdan month) increased significantly [26].

The next important issue is that fasting in the month of Ramadan, affects brain function, and can lead to fatigue, sleepiness, impaired cognition, mood changes and reduced physical performance [27, 28]. In addition, fasting with induced hypoglycemia is associated with an increased risk of accidents [27], as hypoglycemia negatively affects the ability to perform complex activities such as driving and it can be a predictor of traffic accident [29, 30, 31].

Changes in sleep is another important issue, severe nocturnal hypoglycemia can cause abnormal sleep behaviors [32]. During the month of Ramadan, there is approximately 1 h reduction in the total amount of sleep [33]. A comprehensive review of the impairment and accident literature was performed, including 44 relevant publications. Findings from this review suggests that a driver or worker might reasonably be 'deemed impaired' once he or she sleeps less than five hours in 24 h [34]. Interruption of REM sleep is reduced in those who wake up early in the morning to eat Sahur compared to those who may stay up all night to eat it. Moreover, sleeping with a full stomach causes gastroesophageal reflux, affecting sleep quality [35]. Moreover, the decrease in nighttime melatonin level in Ramadan influences the circadian rhythm, but in the case of intermittent fasting, the melatonin circadian pattern does not change much [33, 36].

Although valuable efforts have been made in recent years to identify risk factors for road traffic accidents in northern Iran, less attention has been paid to examining the month of Ramadan as a factor that may contribute to the number of road traffic accidents. Taking a fresh look and paying attention to factors whose effects have not been previously identified is an effort to maintain and promote the health and empowerment of society by increasing traffic safety. It is estimated that a significant number of people fast during Ramadan, this indicates the need for further scientific attention. Therefore, the aim of the present study is to determine what effect fasting during Ramadan has on the number of accidents with damage, injury, and death.

Methods

Setting

This is a descriptive, analytical and retrospective study that was conducted after obtaining the code of ethics from The Research Committee of Guilan University of Medical Sciences (IR.GUMS.REC.1397.302). Guilan province, one of the northern provinces of Iran, with a population of more than 2.5 million people and an area of 14,042 square kilometers, was the place where the study was conducted. This province has 1902 km of roads, 487 km of highways, and 56 km of freeways, and accounts for 3.2% of the country's population and 3.4% of the country's road deaths [3].

At first, the data of all RTAs in the specified time period leading to car damage, injury and death of the occupants or pedestrians and vehicle traffic information were obtained from the database of the Iran Road Maintenance and Transportation Organization and Meteorological Organization in Guilan province. Furthermore, the data related to some confounding variables such as precipitation was obtained from the National Meteorological Organization database in Guilan province

including Rasht (agriculture), Rasht (airport), Bandar-e Anzali, Lahijan, Manjil, amd Astara stations. The criterion for determining the time of the RTAs was the country's general calendar. Regarding the country's official holidays, by referring to the country's official calendar, the holidays were identified and entered into the model. First the collected data were sorted by day and the number of RTAs leading to vehicle damage, and injury and death of people involved for each day from March 21, 2013 to 2016 were identified and calculated. The time period before and after in this study were compared as time series trends in three different years according to the beginning of Ramadan. The data were at gathered daily using time series aggregation method the number of deaths, injuries, amount of rainfall and traffic were gathered daily. For example, we added the number of deaths in a day as a dependent variable in the model. Variables like characteristics of the drivers, socioeconomic conditions, and the quality of roads seems not to change highly in the time. Therefore, we did not use them as confounding factors.

Based on the inclusion criteria, all types of RTAs leading to vehicle damage, injury and death of the involved people that occurred in Guilan province with the following characteristics were included in the study:

2- All RTAs that occurred between April 2014 and April 2017.
3- RTAs of all types of vehicles, whether with local or non-local license plates.

If the data of any RTA obtained from Iran Road Maintenance and Transportation Organization adatabase, had incomplete information on one of the main variables of the study, the accident was excluded from the study.

The data required for this study were collected from two sources:

1. Guilan Meteorological Organization: This data included the mean daily rainfall, (https://www.wunderground.com). The center has up-to-date equipment to measure and record data.

2. Iran Road Maintenance & Transportation Organization: Daily number of RTAs leading to vehicle damage, or injury and death of the people involved, and the amount of traffic were obtained from this local database.

Data analysis
In this study, time series data were collected before and after Ramadan and the daily data of the number of RTAs to vehicle damages, or injuries and deaths of the involved victims in time periods using time series analysis (TSA) were examined. The TSA model used in the present study was:

$$Y_t = \beta_0 + \beta_1 \times_{1t} + \beta_2 \times_{2t} + \beta_3 \times_{3t} + \beta_4 \times_{4t} + \varepsilon_t.$$

Where β_0 donates the constant variable of the model, X_1 donates the total daily traffic density of one road in Guilan province gathered by the online cameras of the Iran Road Maintenance and Transportation Organization, X_2 donates the daily rainfall in the Guilan province, X_3 is a binary variable donates being in holiday or not, X_4 is the binary variable of being in Ramadan or not and ε_t was the residual of the estimated model. Three different dependent variables were added as the Y_t contained daily number of deaths, daily number of injuries and daily number of accidents. Due to having count data as the dependent variable, Poisson estimator was used for running the regression model. All estimations and analyses were performed using STATA SE v13.1 software. A significance level of less than 0.05 were selected.

Results
The average mortality rate was 1.51 ± 2.10 and 1.82 ± 3.09 in Ramadan and in other months, respectively. However, the average number of accidents and injuries in the month of Ramadan was 42.16 ± 17.72 and 30.61 ± 13.90, respectively, and in other months it was 40.26 ± 17.19 and 26.77 ± 13.64, respectively, which indicates the increase in accidents and injuries in the month of Ramadan and decrease in mortality in Ramadan than other months (Table 1).

The number of traffic accidents during the daytime in the month of Ramadan was 27.24 ± 1.14 on average and 24.77 ± 0.34 in other months, which means that the number of traffic accidents during the day in the month of Ramadan was significantly higher than that of other months (p-value $= 0.040$). The average number of injuries during the day in the month of Ramadan was 18.31 ± 0.84 and 15.40 ± 0.26 in other months. The number of injuries in Ramadan significantly increased (p-value $= 0.001$). There was no significant association between the average mortality rate during daytime hours in Ramadan and other months (p-value $= 0.67$).

The average traffic in terms of car numbers was 19690.28 ± 506.63 in Ramadan and 21096.69 ± 134.43 in

Table 1 Comparing traffic accidents, injuries and mortalities in Ramadan with other months

Variable	Mean	SD	Lowest	Highest
Other months				
Mortality	1.82	3.09	0	32
Traffic accident	40.26	17.19	2	119
Injury	26.77	13.64	1	84
Ramadan				
Mortality	1.51	2.10	0	8
Traffic accident	42.16	17.72	10	121
Injury	30.61	13.90	3	77

other months, which was significantly higher than the average traffic in other months (*p*-value = 0.002). The average speed of cars in Ramadan was higher, and this difference was about 2 km per hour, which was not significant. The speed of vehicles in Ramadan was not different from other months (*p*-value = 0.09) (Table 2).

Table 3 shows the results of regression analysis. the dependent variable (the daily number of accidents and daily number of injuries) was in count form, so we analyzed the results using Poisson regression, In Poisson the exponential form of the coefficient is called incidence rate ratio (IRR). If the value of IRR is near 1, the explanatory variable has zero relationship with the dependent variable. IRRs higher than 1 shows positive relationship and IRRs less than 1 shows negative relationship with the dependent variable. As indicated in Table 3, there was a significant direct relationship between the number of accidents per day and the amount of traffic (95%) however it was not strong. For every thousand cars, the likelihood of accidents increased by 1% (*p*-value = 0.000). A significant relationship was found between the number of accidents per day and the average amount of rainfall, (above 95%). The relationship was direct, and for every 1 mm of rainfall, the likelihood of accidents increased by 0.4% (*p*-value = 0.000). A significant direct association existed between the number of accidents per day and the month of Ramadan (95%), and the likelihood of accidents increased by 14% for being in the month of Ramadan (*p*-value = 0.000).There was a significant direct relationship between the number of accidents per day and being on holiday (above 95%). The likelihood of accidents increased by 13% for being on holiday (*p*-value = 0.000). IRR states that if the conditions (rainfall, being on holiday, car traffic) are the same in Ramadan and other months, the number of accidents in Ramadan is higher than that of other months (Table 3).

A significant, direct relationship was observed between the number of injuries and the amount of traffic per day, and for every ten thousand cars, the likelihood of daily injuries increased by 2% (*p*-value = 0.000). Furthermore, a significant relationship was reported between the number of injuries per day and the average daily rainfall (above 95%). This relationship was inverse, and for each millimeter of rainfall, the likelihood of injuries reduced by 0.2% (*p*-value = 0.000). There was a significant direct relationship of over 95% between the number of injuries per day and being in Ramadan month. There was a 19% increase in the likelihood of injuries due to being in Ramadan (*p*-value = 0.000). We also found a significant, direct relationship between the amount of injuries per day and being on holiday, which was above 95%. For every day of being on holiday, the likelihood of injuries increased by 10% (*p*-value = 0.000).

Table 2 Comparing average daily traffic accidents, injuries, mortalities, traffic and vehicle speed in Ramadan and other months

Variable	Mean	SD	Lowest	Highest
Daily traffic accident				
Other months	24.77	0.34	24.09	25.45
Ramadan	27.24	1.14	24.97	29.52
Difference	-2.47	1.20	-4.83	-0.10
p-value = 0.040				
Daily injury				
Other months	15.40	0.26	14.89	15.92
Ramadan	18.31	0.84	16.63	19.99
Difference	-2.90	0.90	-4.68	-1.12
p-value = 0.001				
Daily Mortality				
Other months	0.89	0.05	0.78	0.99
Ramadan	0.96	0.15	0.66	1.27
Difference	-0.07	0.18	-0.43	0.28
p-value = 0.67				
Traffic				
Other months	21096.69	134.43	208332.91	21360.47
Ramadan	19690.28	506.63	18686.04	20694.52
Difference	1406.41	462.39	499.25	2313.57
p-value = 0.002				
Speed				
Other months	74.56	0.27	74.02	75.10
Ramadan	76.08	0.25	75.57	76.59
Difference	-1.52	0.89	-3.28	0.24
0.09 = *p*-value				

Table 3 Daily accidents according to different variables in Guilan between 2013 to 2016

Daily RTAs	IRR	SD	P-value	[95% Conf. Interval]	
				Lower limit	Upper limit
Traffic	1.000	0.000001	< 0.001	1.000017	1.000022
Rainfall	1.004	0.001	< 0.001	1.002	1.006
Ramadan	1.141	0.021	< 0.001	1.098	1.185
Holiday	1.136	0.015	< 0.001	1.106	1.166
Constant	16.075	0.463	< 0.001	15.192	17.010

IRR states that if the conditions (rainfall, being on holiday, traffic) are the same in Ramadan and other months, the number of injuries in Ramadan is higher than that of other months (Table 4).

According to the above table, there was a significant direct relationship between mortalities per day and traffic, (above 95%). For every thousand vehicles, the likelihood of death increased by 2% (*p*-value = 0.000). There was no significant relationship between daily mortality and rainfall (*p*-value = 0.342) and being in the month of Ramadan (*p*-value = 0.210). Moreover, a significant, direct relationship was present between the daily death rate and being on holiday, (above 95%). Every day of being on holiday increased the likelihood of death by 23%(*p*-value = 0.002).

Table 4 Daily injuries according to different variables in Guilan between 2013 to 2016

Daily injury	IRR	SD	P-value	[95% Conf. Interval]	
				Lower limit	Upper limit
Traffic	1.00	0.0000063	0.000	1.000025	1.000031
Rainfall	0.988	0.001	0.000	0.985	0.992
Ramadan	1.190	0.027	0.000	1.136	1.246
Holiday	1.101	0.018	0.000	1.065	1.138
Constant	8.845	0.325	0.000	8.229	9.506

Table 5 Daily mortalities according to different variables in Guilan between 2013 to 2016

Daily mortality	IRR	SD	P-value	[95% Conf. Interval]	
				Lower limit	Upper limit
Traffic	1.000025	-06E6.74	0.000	1.000012	1.000039
Rainfall	0.993	0.006	0.342	0.981	1.0065
Ramadan	1.133	0.112	0.210	0.932	1.377
Holiday	1.234	0.084	0.002	1.078	1.412
Constant	0.526	0.080	0.000	0.390	0.709

The IRR states that if the conditions (rainfall, being on holiday, car traffic) are the same in Ramadan and other months, the death rate in Ramadan is not different from other months (Table 5).

Discussion

In the current study, the results of the average of total RTAs and average daily RTAs indicated a higher number of RTAs in the month of Ramadan, which is in line with the study of San San Tan (2023), who confirmed that hypoglycemia in the month of Ramadan can affect the ability to perform complex activities such as driving [29]. This finding is contrary to the results of the study of Yousefifard et al. (2021), who in a retrospective study discovered that in Ramadan, the rate of patient admission to the emergency departments decreased [26].

In our study, the average of total and average daily injuries in Ramadan compared to other months shows an increase in the amount of injuries, which was contrary to the findings of the study of Mahmood et al. (2015) who found that road accidents during Ramadan in Karachi, Pakistan did not change significantly for the years 2006 and 2011 [37]. The results were also incompatible with findings of Khammash and Al-Shouha (2006), who stated that road injuries in the month of Ramadan decreased significantly compared to other times of the year [38]. In Al Ain and United Arab Emirates, the number of persons injured by traffic accidents was slightly higher during Ramadan [39] and it is in line with the results of Langford's study, which shows a significant increase in the number of Muslims admitted to the emergency departments during Ramadan [40]. Malnutrition caused by fasting can affect driver's concentration, attention span,

reactions and physical and cognitive capacities of the driver (e.g. reduced driving capacity) and increase the risk of accidents [5]. In addition, lack of sleep is another risk of traffic accidents in Ramadan [41]. Sleep was an important factor contributing to traffic collisions during Ramadan in the UAE [42].

In the present study, the average of total and daily average deaths due to RTAs in Ramadan was lower than that of other months, but the difference was not significant. The study by Alsofayan and his colleagues (2022) indicated a significant difference in terms of accidents, injuries and even deaths in Ramadan [27]. Studies in Pakistan, Turkey and UAE confirmed the results of our study [5, 37, 39].

Several mechanisms are responsible for the increasing traffic accidents and deaths caused by RTIs during Ramadan. In the late afternoon and near the time of Iftar, fatigue, and cognition along with mood changes are observed [27] probably caused by hunger, dehydration, and lack of sleep [41]. Sleepiness can decrease mental alertness and increase the need to take short naps during the day [43], leading to a decline in vision and memory [21].

Another reason for the increase in RTI in Ramadan stems from the change in the behavior of drivers. The reports show less use of seat belts in Ramadan. However, horn honking is more. This can increase the irritability of other thirsty and hungry road users in traffic [22, 27]. Another dangerous behavior during Ramadan was speeding by drivers in Pakistan [23, 27].

Although in the current study, the number of traffic accidents and injuries increased during Ramadan, the death rate was less than other studies. This new and unique finding is specific to Iran, unveiling that there are factors in the country that decrease the severity of accidents in Ramadan than other months. It is necessary to identify these factors in future studies and even strengthen them.

In the current study, the variables of traffic, rainfall, being in Ramadan and holidays were significantly related to more RTAs and injuries. In addition to strengthening the findings of the same study regarding the increase in traffic accidents and injuries in Ramadan, this finding indicates that Ramadan is an important and effective variable in traffic accidents and injuries, if the variables of traffic, rainfall, and holidays are kept constant. This finding has been both confirmed and rejected in previous studies. Studies confirming an existing increasing trend in traffic accidents have been in countries that celebrate Ramadan, Eid al-Fitr and Eid al-Adha [23, 36].

In our study, the amount of traffic increased significantly in Ramadan compared to other months, but the speed of vehicles, although increased, was not significant. It was previously reported that in Ramadan, people

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have more daily travels than other months to provide the necessary food for the Iftar or to go to the Iftar party, potentially leading to more traffic accidents (Alsofayan, Alghnam et al. 2022).

In a study on 2106 drivers at an intersection, the findings revealed that in Ramadan, their average speed was lower than that of the usual time, seat belt was used less, and honking was more [22]. The higher number of traffic accidents and injuries in the month of Ramadan exhibits that so far in Iran, not enough attention has been paid to Ramadan as a contributing factor to traffic accidents and injuries to be prevented and intervened. Fasting is a key factor and as important as other causes of traffic such as rain and holidays can increase traffic accidents and injuries.

Limitation

One of the limitations of this study was its retrospective nature because some information about fasting and its related clinical changes in those who had a traffic accident were incomplete or unavailable such as changes in psychomotor characteristics and sleep rhythm, and low blood sugar.

Conclusion

Traffic-related injuries and accidents as well as heavy traffic significantly increased in the month of Ramadan compared to other months, so regulatory organizations and institutions responsible for traffic safety in Muslim country are expected to make the necessary forecasts before Ramadan begins and plan in advance to reduce the related accidents and injuries. In addition, people in developing countries like Iran should be informed about being more careful in driving while fasting during Ramadan. Obeying traffic rules by drivers should be more monitored during Ramadan. The traffic police should control traffic and consider penalty for wrongful drivers. Similar measures can help in reducing traffic accidents and injuries not only during Ramadan but also the overall rate of such incidents in all month.

Declarations

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