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Analysis of Road Traffic Crashes in the State of Qatar

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Abstract

In the State of Qatar, different seasons are characterized by extremely varying weather conditions. The rate and severity of road traffic crashes (RTCs) vary based on weather conditions which affects the behaviour of road users. Road traffic crash data of seven consecutive years, ranging from 2010 to 2016, for the State of Qatar is obtained from the Traffic Department in the Ministry of Interior and has been statistically analyzed. This study aims to investigate RTC causes and whether they vary between seasons in the State of Qatar. Results indicate that the majority of RTCs are caused by reckless driving, followed by crossing a road without giving priority and deviation from the traffic lane. Moreover, the season that is more prone to crashes differs per RTC cause. This study also aims to investigate if there is a relationship between different types of RTCs and seasonal variation in the State of Qatar. The results revealed that crashes with severe injuries or fatality for drivers as well as pedestrians are found to be significantly affected by different seasons, with the highest vulnerability in winter and autumn season. This study therefore suggests the implementation of strategies to prioritize the traffic safety of road users during the crash-prone winter and autumn seasons.

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Keywords: Road traffic crash; Seasonal effect; Crash severity, State of Qatar

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1. Introduction and background

Road traffic crashes (RTCs) are posing a serious hazard to modern societies, as they result in injuries, disabilities and even loss of lives, along with significant economic and social problems. Globally, RTCs led to about 1.3 million fatalities per year, with an average of 3,287 deaths per day as stated by World Health Organization's (WHO) global status report on road safety [1]. In the Arabian Gulf countries, RTCs are recognized as a growing threat to the community and thus received increased importance and attention. Various specified engineering measures are being implemented and awareness campaigns are being carried out in this region with the aim to minimize the severity and

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number of crashes. One example is Qatar's road safety strategy 2013-2022, which has been developed in accordance with the underlying principle intending to ensure that any crash that occurs does not result in fatality or serious injury.

Despite the reduction in the number of crashes during the last five years, the frequency of personal injuries and material damage caused by road crashes involving a minimum of one vehicle has increased in the country [2]. Therefore, it is significant to create understanding about the nature of the fatal crashes and crashes with serious injuries, by identifying different salient factors that influence the number of RTCs. A RTC can be caused by different factors related to road conditions, traffic density, vehicle conditions and human errors. The main causes of RTCs identified in the Gulf region are human factors such as driver negligence, aggressive driving, violation of traffic regulations, and speeding [3]. RTCs can be studied with different data collection methods and a variety of statistical analysis. For example, the monthly evaluation of RTCs is important when considering the effect of seasonal variation throughout the year. This is interesting to study, because approximately 5 percent of the RTCs occur due to factors related to various weather condition [4]. The frequency of RTC is found to be related to different weather conditions and its consequences such as snow [5], winter storms [6] and rainfall [7,8]. This is in line with a variety of previous studies in which the RTC rate depends on monthly and daily differences in weather conditions [5,9], such as the effect caused by windy weather [10], wintery weather [11,12] and the amount of sunshine [13]. Hence, it can be suggested that the RTC rate of a specific region could be subjected to the distinctive characteristics of that region. The State of Qatar, among other countries in the Gulf region has a hot, humid and dry subtropical desert climate with low annual rainfall. Seasons in the State of Qatar and other Gulf countries are characterized by varying weather conditions and the year could be divided into four seasons [14]. The beginning of each year starts with a mild winter season during the months December, January and February with lower average temperatures ranging from 22℃ to 24℃. During the months March, April and May the spring season starts with average temperatures warming up from 27℃ to 38℃ at the end of the season. The summer season in the State of Qatar has the most extreme temperatures ranging 38℃ in June, increasing to an average daytime temperature of 41℃ in July, and August has the highest temperatures of the year reaching 43℃ at noon. The autumn season covers the months September, October and November with daily temperatures decreasing after the summer period from 39℃ in September to 29℃ in November. In essence, during summer period the weather is hot with high humidity and this affects the behaviour of road users. For instance, few pedestrians would go out and walk on the streets as the temperatures are unbearable, in contrast to the autumn and winter period were the number of pedestrians increase due to the pleasant mild temperatures [14]. Rainfall is rare in the State of Qatar, but is most likely to occur during the rainy season also known as 'Wasmi season' which occurs in autumn during the months October and November [15]. According to the Qatar Meteorology Department autumn and winter season are also characterized by mist or fog at dawn and in the early morning due to northeaster or southeaster winds causing humidity [16]. One hundred and thirteen RTCs that occurred due to the thick fog have been reported in the State of Qatar in 2016 [17] and a similar cause was reported for more than 500 RTCs in Dubai in February 2018 [18]. In line with this, Seasonal variation was reported as a causal factor for the high number of RTCs in Saudi Arabia [19].

Nonetheless, despite the previous research studying the frequency of RTCs and its related causes, there is a gap in the literature with regards to the correlations between Road Traffic Crashes and their cause in the Arab Gulf region, specifically for the effect of seasonal variation on the crash rate. Therefore, the first objective of this study is to investigate if there is a relationship between different types of RTCs and seasonal variation in the State of Qatar. The second objective is to examine RTC causes and whether they differ between the various seasons.

2. Methodology

The state of Qatar has an area of 11,437 km^2, with a population of about 2.55 million as of September 2016 where fourteen percent are native (Qatari), and eighty six percent are foreigners. More than eighty to ninety percent of the population is concentrated in less than 15% of the geographic area as indicated in dots in Figure 1 [20]. Based on the data, the number of active driving licenses in 2016 was 1,328,973 recorded by the Ministry of Interior (MOI). The present study is based on data obtained from the Traffic Department in the MOI. The data encloses the numbers of different types of RTCs and their causes, which occurred within the State of Qatar on a monthly basis for a period of seven consecutive years from 2010 to 2016. The RTC frequency data for the different types of crashes for all seven years (ranging from 2010 to 2016) was divided into four seasons (i.e. winter, spring, summer and autumn). Winter season contained the months December, January and February, spring season consisted of the months March, April

and May, summer season was labelled for the months June, July and August and autumn season for the months September, October and November. The crash rate of a specific season is taken as the ratio of the observed crash frequency during that season to the total crash frequency recorded for the corresponding year.

At first, descriptive analysis is performed to indicate the monthly frequency of crashes with severe injuries and crashes with fatalities, comparing seven years of data from 2010 to 2016. An outlier analysis was performed revealing no outliers among the RTC frequency per month and per year for severe injury RTC or fatal RTC. Moreover, the contributions of different RTC causes for both fatal crashes and severe injury crashes are evaluated using descriptive analysis. The descriptive analysis is then followed by two MANOVA analyses to investigate the relationship between seasonal variations and RTCs. The first MANOVA analysis measures 6 different RTC types (either severe injury RTC or fatal RTC with three victim types being driver, passenger or pedestrian) as dependent variables and the four seasons as independent variables. The same independent seasonal variable was used to conduct the second MANOVA analysis with 19 causes for severe injury RTC and 19 causes for fatal RTC as dependent variables. Statistical analysis were conducted using SPSS with a significance level of $\alpha = 0.05$.

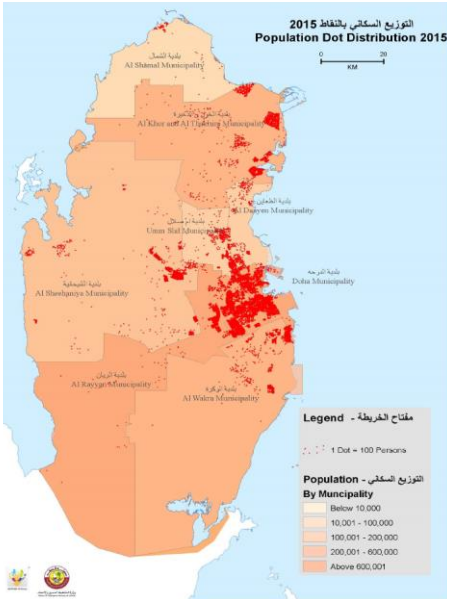
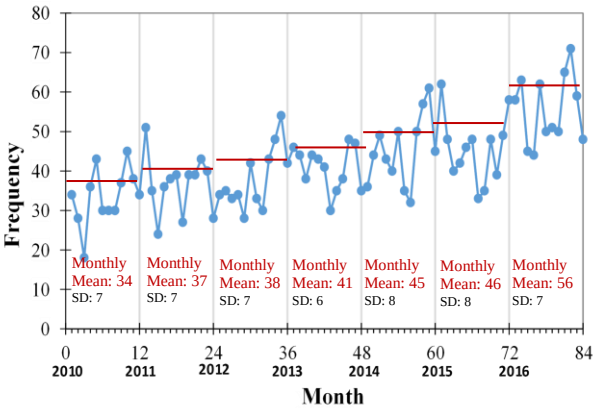


Figure 1: Population density in the State of Qatar [20]

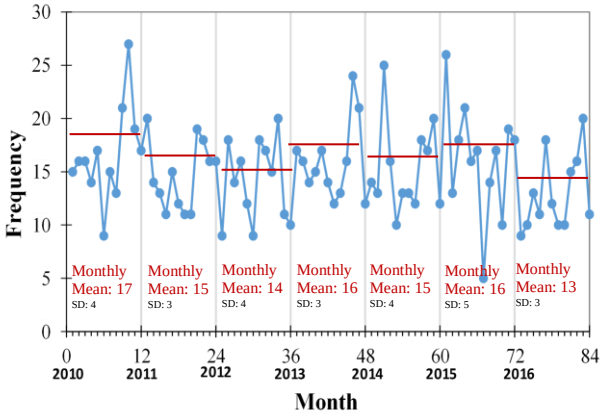
3. Results and Discussion

3.1. Descriptive statistics

Figures 2a and 2b depict a time history plot starting from January 2010 (0 in Figures 2a and 2b) until December 2016 for the frequency of monthly severe injury crashes and fatal crashes in the State of Qatar, respectively. The results indicate an increasing trend observed for the number of crashes with severe injury, but no clear trend has been observed for crashes with fatalities as can be seen in Figures 2a and 2b, respectively. Figure 2a and 2b also presents the mean and standard deviation of the monthly fatal and severe injury RTC rate per year from 20. The results show an increasing trend in the average monthly severe injury crashes from 34 crash per month in 2010 to 56 crash per month in 2016, this reflects an increase of 65%. However, for fatal crashes the annual monthly average shows higher variation over the seven year period, with decreasing and increasing trends and a final significant drop in 2016.

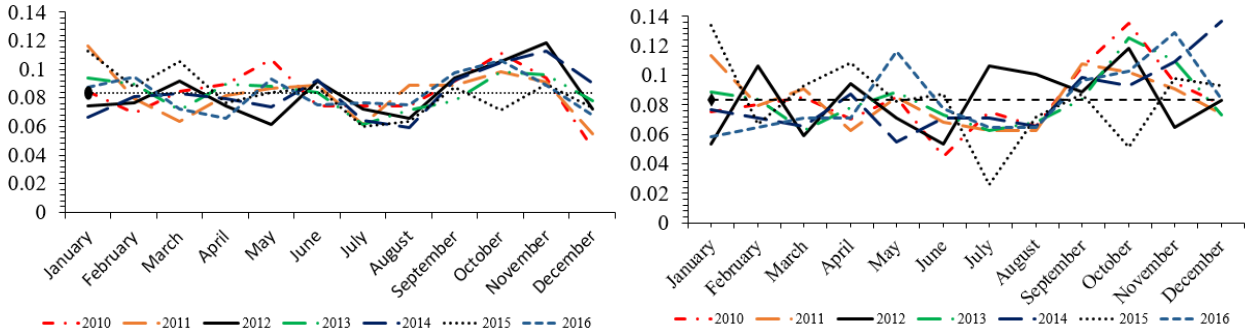


(a) Severe injury crashes versus month



(b) Fatal crashes versus month

Figure 2: Time history with mean and standard deviation of the monthly severe injury and fatal RTC frequency per year in the State of Qatar.



(a) Severe injury crashes versus month (b) Fatal crashes versus month

Figure 3: Percentage of monthly fatal and severe injury crashes in the state of Qatar.

Table 1. Summary of MANOVA for significant relationships between seasonal variation and different RTC types, comparing average RTC rate

RTC type	Significant Seasonal effect			Average crash rate				Ranking RTC prone seasons
	F (seasonal effect)	df	Significance	Winter (1)	Spring (2)	Summer (3)	Autumn (4)	
Severe injury (Driver)	6.989**	3	p= .002	0.270	0.218	0.249	0.263	1-4-3-2
Fatal (Driver)	3.490*	3	p= .031	0.257	0.220	0.226	0.298	4-1-3-2
Severe injury (Pedestrian)	3.514*	3	p= .030	0.281	0.240	0.224	0.255	1-4-2-3
Fatal (Pedestrian)	3.013*	3	p= .050	0.298	0.273	0.190	0.239	1-2-4-3

*Significant at α< .05 **Significant at α< .01

To investigate the seasonal variations, Figures 3a and 3b are presented. Figure 3a shows the monthly percentage of severe injury crashes per year from 2010 to 2016, while Figure 3b shows the monthly percentage of fatal crashes per year during the same period. It is visualized that there is an increase in the percentage of fatal and severe injury crashes during the months of September, October and November. The percentage of crashes in these specific months are noticeably higher than the remaining months as shown in Figures 3a and 3b.

3.2. Relationship between seasonal variation and RTC frequency

A MANOVA analysis was carried out to investigate the relationship between seasonal variation and monthly crash frequency, for crashes of passenger, driver and pedestrian resulting in severe injury or fatality. Table 1 provides the result of the analysis. The results indicate that there is no significant relationship between the seasonal variation and crashes that yielded to casualty or severe injury for the passenger. However, seasonal variation does have a significant effect on the frequency of crashes that yielded to fatality or severe injuries for the driver and crashes with severe injuries and fatalities for pedestrians as listed in Table 1.

The impact of seasonal variation on RTCs indicates the importance for further evaluation of the most crash-prone season and how this season differs from the rest. Therefore, Table 1 also lists the comparison of the four seasons' average RTC rate for the fatal crash and severe injury crash types that reveal a significant relationship with seasonal variation. From the results, it is observed that autumn and winter season are most prone for both severe injury and fatal RTC for drivers. During these seasons the weather in the State of Qatar is characterized by a heavy wind and dense fog, especially during the night and early morning, resulting in reduced visibility. Also during autumn season the State of Qatar is also most likely to have rainfall during 'Wasmi season'[15].

Winter season followed by autumn or spring season are also the most crash-prone seasons for pedestrian victims with the highest number of severe injury RTC and fatality RTC. During winter and autumn season temperatures are pleasant which encourages walking, besides during these seasons more outdoor activities are organised which leads to an increase of pedestrian flow. Furthermore, schools are closed for summer season and many residents spend time indoors or leave the country for holiday, which leads to significantly less pedestrian fatality or severe injury RTCs during summer season. In a previous study on the impact of crashes on pedestrians, it was concluded that the diverse

Table 2. Number and percentage of different of RTC causes for severe injury crashes

RTC cause	Year						
	2010	2011	2012	2013	2014	2015	2016
Dangerous driving behaviour	32 (7.94%)	14 (3.19%)	25 (5.48%)	13 (2.63%)	17 (3.14%)	12 (2.19%)	2 (0.3%)
Crossing a road without giving priority	42 (10.42%)	32 (7.29%)	51 (11.18%)	52 (10.53%)	49 (9.04%)	43 (7.85%)	51 (7.66%)
Cutting lights	10 (2.48%)	2 (0.46%)	9 (1.97%)	6 (1.21%)	17 (3.14%)	17 (3.1%)	23 (3.45%)
Deviation from driving lane	30 (7.44%)	39 (8.88%)	46 (10.09%)	49 (9.92%)	39 (7.2%)	47 (8.58%)	53 (7.96%)
Drifting	0 (0%)	1 (0.23%)	1 (0.22%)	1 (0.2%)	1 (0.18%)	0 (0%)	1 (0.15%)
Driving the car in a dangerous way (racing)	0 (0%)	0 (0%)	0 (0%)	1 (0.2%)	10 (1.85%)	7 (1.28%)	0 (0%)
Driving under the influence of alcohol or suspicion of under alcohol effect	11 (2.73%)	16 (3.64%)	7 (1.54%)	10 (2.02%)	17 (3.14%)	7 (1.28%)	11 (1.65%)
Driving without a valid licence	5 (1.24%)	2 (0.46%)	7 (1.54%)	8 (1.62%)	10 (1.85%)	13 (2.37%)	3 (0.45%)
Driving in the opposite direction	3 (0.74%)	1 (0.23%)	2 (0.44%)	0 (0%)	3 (0.55%)	0 (0%)	1 (0.15%)
Escape from the crash scene	6 (1.49%)	5 (1.14%)	10 (2.19%)	9 (1.82%)	9 (1.66%)	6 (1.09%)	6 (0.9%)
Failure to follow the right lane	1 (0.25%)	1 (0.23%)	4 (0.88%)	1 (0.2%)	7 (1.29%)	4 (0.73%)	6 (0.9%)
none secure vehicle stop with hand brake	1 (0.25%)	3 (0.68%)	1 (0.22%)	1 (0.2%)	2 (0.37%)	2 (0.36%)	3 (0.45%)
Reckless driving	207 (51.36%)	243 (55.35%)	223 (48.9%)	261 (52.83%)	268 (49.45%)	315 (57.48%)	388 (58.26%)
Not leaving sufficient distance	26 (6.45%)	33 (7.52%)	36 (7.89%)	46 (9.31%)	51 (9.41%)	40 (7.3%)	68 (10.21%)
Over speed	7 (1.74%)	7 (1.59%)	5 (1.1%)	3 (0.61%)	5 (0.92%)	0 (0%)	2 (0.3%)
Reversing	5 (1.24%)	8 (1.82%)	8 (1.75%)	2 (0.4%)	8 (1.48%)	8 (1.46%)	15 (2.25%)
Sudden stop	1 (0.25%)	0 (0%)	0 (0%)	0 (0%)	2 (0.37%)	0 (0%)	0 (0%)
Wrong overtaking	10 (2.48%)	17 (3.87%)	16 (3.51%)	18 (3.64%)	14 (2.58%)	12 (2.19%)	16 (2.4%)
Others	6 (1.49%)	15 (3.42%)	5 (1.1%)	13 (2.63%)	13 (2.4%)	15 (2.74%)	17 (2.55%)

Note: Figures in parentheses indicate the percentage of crashes relative to the total crashes in the corresponding year.

population with different cultural backgrounds that characterizes the State of Qatar, leads to different pedestrian walking and road crossing behaviours which contributed to severe traffic conflicts between vehicles and pedestrians [21]. In general, it can be concluded that pedestrians are vulnerable to RTCs, therefore efficient management of pedestrian flows is essential to reduce the number of pedestrian fatalities.

In conclusion, the combined effect of reduced visibility and pleasant outdoor temperatures during winter and autumn are seasonal factors which lead to different behaviours among road users and could explain the higher rate of severe injury and fatal crashes for both pedestrians and drivers.

3.3. RTC causes

It is vital to clearly identify the causes of RTCs in order to provide compatible countermeasures. The data used for this study only includes crashes caused by factors related to the driver. In the database, 19 different types of causes of RTCs are reported, as listed in Table 2 and Table 3 for crashes with severe injury and crashes with fatalities, respectively.

Results in Table 2 show that reckless driving is the major cause of severe injury crashes in the State of Qatar, causing almost half of the severe injury crashes alone. This indicates that further investigation should be done to identify causes that might lead drivers to increase their willingness to drive recklessly and to identify proper countermeasures with their effective implementation procedures. In addition, more attention should be given to other

Table 3. Number and percentage of different RTC causes for fatal crashes

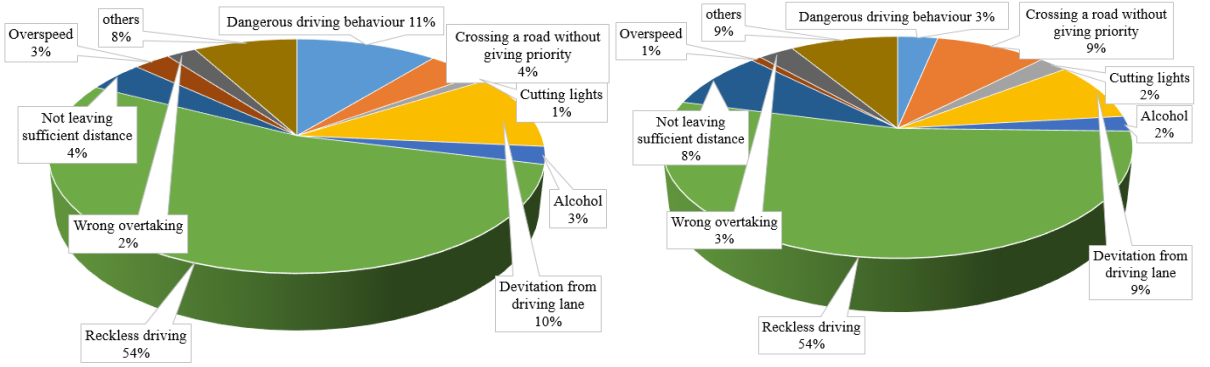
RTC cause	Year						
	2010	2011	2012	2013	2014	2015	2016
Dangerous driving behaviour	25 (12.56%)	26 (14.77%)	22 (13.02%)	16 (8.38%)	19 (10.33%)	25 (12.89%)	5 (3.23%)
Crossing a road without giving priority	8 (4.02%)	11 (6.25%)	10 (5.92%)	7 (3.66%)	6 (3.26%)	4 (2.06%)	7 (4.52%)
Cutting lights	0 (0%)	1 (0.57%)	2 (1.18%)	2 (1.05%)	2 (1.09%)	4 (2.06%)	1 (0.65%)
Deviation from driving lane	11 (5.53%)	19 (10.8%)	24 (14.2%)	34 (17.8%)	15 (8.15%)	15 (7.73%)	14 (9.03%)
Drifting	0 (0%)	0 (0%)	1 (0.59%)	1 (0.52%)	1 (0.54%)	0 (0%)	0 (0%)
Driving the car in a dangerous way (racing)	2 (1.01%)	1 (0.57%)	0 (0%)	0 (0%)	3 (1.63%)	0 (0%)	0 (0%)
Driving under the influence of alcohol or suspicion of under alcohol effect	5 (2.51%)	4 (2.27%)	3 (1.78%)	9 (4.71%)	3 (1.63%)	5 (2.58%)	2 (1.29%)
Driving without a valid licence	1 (0.5%)	3 (1.7%)	0 (0%)	2 (1.05%)	4 (2.17%)	2 (1.03%)	0 (0%)
Driving in the opposite direction	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (0.54%)	0 (0%)	0 (0%)
Escape from the crash scene	3 (1.51%)	2 (1.14%)	1 (0.59%)	1 (0.52%)	4 (2.17%)	2 (1.03%)	1 (0.65%)
Failure to follow the right lane	1 (0.5%)	2 (1.14%)	0 (0%)	0 (0%)	2 (1.09%)	1 (0.52%)	0 (0%)
none secure vehicle stop with hand brake	1 (0.5%)	0 (0%)	1 (0.59%)	1 (0.52%)	1 (0.54%)	0 (0%)	0 (0%)
Reckless driving	112 (56.28%)	81 (46.02%)	72 (42.6%)	97 (50.79%)	92 (50%)	114 (58.76%)	113 (72.9%)
Not leaving sufficient distance	8 (4.02%)	4 (2.27%)	6 (3.55%)	8 (4.19%)	14 (7.61%)	8 (4.12%)	6 (3.87%)
Over speed	8 (4.02%)	7 (3.98%)	8 (4.73%)	4 (2.09%)	3 (1.63%)	5 (2.58%)	1 (0.65%)
Reversing	2 (1.01%)	5 (2.84%)	3 (1.78%)	2 (1.05%)	2 (1.09%)	2 (1.03%)	2 (1.29%)
Sudden stop	0 (0%)	0 (0%)	0 (0%)	1 (0.52%)	0 (0%)	0 (0%)	0 (0%)
Wrong overtaking	4 (2.01%)	3 (1.7%)	7 (4.14%)	3 (1.57%)	3 (1.63%)	6 (3.09%)	3 (1.94%)
Others	8 (4.02%)	7 (3.98%)	9 (5.33%)	3 (1.57%)	9 (4.89%)	1 (0.52%)	0 (0%)

Note: Figures in parentheses indicate the percentage of crashes relative to the total crashes in the corresponding year.

major road crash causes such as crossing the road without giving priority, not leaving sufficient distance, and deviation from driving lane. These three causes in combination lead to around 25 percent of the total severe injury related crashes. Similarly, results in Table 3 show that reckless driving is also the leading cause of fatal crashes in the State of Qatar. Dangerous driving behaviour and deviation from driving lane are also major causes for fatal crashes.

Alongside, Figure 4 shows the major causes of RTCs that led to severe injuries and fatalities during the period from 2010 to 2016. As evident in this Figure, for both levels of crash severity, more than 50 percent of the RTCs are caused by reckless driving, followed by crossing a road without giving priority, dangerous driving behaviour, and deviation from the traffic lane.

A MANOVA analysis is conducted to investigate whether the causes of RTCs in the State of Qatar differ per season. Table 4 shows the significant results and compares the average rate of RTCs during the four different seasons. The result of the MANOVA analysis revealed that 8 out of 19 RTC causes are affected by seasonal variation, as listed in Table 4. The season most prone to crashes differs per RTC cause; for instance, during winter season cutting lights, reckless driving which includes neglect or lack of attention and other causes are most frequent. Spring season is most prone to RTCs causing an injury because of dangerous driving and the RTC cause deviation from driving lane. The RTC cause driving under influence of alcohol is most frequent during Autumn season followed by winter season, which can be explained by more residents going out in the evening to restaurants or bars during these seasons. Summer season is more prone to RTCs caused by sudden stopping, but to understand this relationship this RTC cause requires more detailed analysis. In general it is recommended for further research to investigate which RTC causes relate to the severity of the RTC and if season also impacts the RTC causes for RTCs with different types of severity.



(a) Severe injury crashes (b) Fatal crashes

Figure 4: RTC by cause (years 2010 to 2016).

Table 4. Summary of MANOVA for significant relationships between seasonal variation and causes of total RTC

Causes for RTC	Significant Seasonal effect			Average crash rate				Ranking RTC prone seasons
	F (seasonal effect)	df	Significance	Winter (1)	Spring (2)	Summer (3)	Autumn (4)	
Dangerous driving behaviour	6.216**	3	p= .003	0.287	0.313	0.201	0.198	2-1-3-4
Cutting lights	3.751*	3	p= .024	0.319	0.197	0.225	0.260	1-4-3-2
Deviating from driving lane	6.321**	3	p= .003	0.247	0.281	0.225	0.247	2-4-1-3
Driving under influence of alcohol	4.026*	3	p= .019	0.274	0.235	0.190	0.300	4-1-2-3
Reckless driving (incl. neglect and lack of attention)	23.079***	3	p= .000	0.269	0.254	0.224	0.254	1-4-2-3
Overspeeding	5.139**	3	p= .007	0.323	0.266	0.301	0.110	1-3-2-4
Sudden stop	3.059*	3	p= .048	0.119	0.305	0.405	0.029	3-2-1-4
Other causes	3.471*	3	p= .032	0.323	0.227	0.206	0.244	1-4-2-3

*Significant at α< .05 **Significant at α< .01 ***Significant at α< .001

4. Conclusions

This study investigates road traffic crashes (RTCs) in the state of Qatar for a period of seven consecutive years from 2010 to 2016. Results reveal that the total number crashes with severe injuries show an increasing trend from the year 2010 to 2016. Furthermore, it is found that reckless driving contributes to more than 50% of severe injury and fatal crashes. Other major causes of severe injury RTC as well as fatal RTCs include crossing a road without giving priority, dangerous driving behaviour and deviation from the traffic lane. Furthermore, determining which season is more prone to crashes, largely depends on the RTC cause. The effect of seasonal variation on six different types of RTCs (severe injury or fatality of either drivers, passengers or pedestrians) has also been investigated. The results of the MANOVA analysis revealed that there is a significant relationship between RTC type and seasonal variation for crashes resulting in severe injury and fatality of both the driver and pedestrians. Moreover, the analysis indicates that winter and autumn season are most prone to RTC crashes.

In conclusion, this study suggests the need for the provision of a critical, strategic plan to prioritize the traffic safety, especially following the crash-prone winter and autumn season. However, to identify proper countermeasures to improve safety levels, future research is required with in-depth analysis of crash causes and crash patterns during each season within the State of Qatar future.

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