

Road Safety Modeling in Kuwait

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Abstract

Location and time-period can highly be correlated with traffic accidents types. In this study, 287983 traffic accidents that happened in 2013, 2014, 2016, and 2017 were collected from General Traffic Department of Kuwait. The collected traffic accidents occurred in four- governorates that included Kuwait-City, Hawally, Al Farwaniya, and Al Ahmadi as those governorates had the highest rate of traffic accidents. The types of traffic accidents that were included in the collected data were crashes, run-over, and rollover accidents. Afterward, the location and the year where and when the accident occurred were chosen to be the independent variable and the dependent variable was the type of accident. Then, a multinomial logit regression model was applied to identify the significant independent variable and the correlations between predictors and the dependent variable. The results showed that both location and time were significant variables that influence the occurring of certain types of accidents. According to the model results, rollover accidents had higher odds of happening in Al Ahmadi governorate. While for the time-period, 2017 was found to have a higher probability of run-over accidents occurring.

Keywords

Traffic accidents, multinomial logit model, location, time-period, Kuwait

1. Introduction

Traffic accidents are one of the highest reason for causing death around the globe. According to World Health Organization data (Global Health Observatory 2017), Kuwait had the third highest death rate related to traffic accidents with 18.7 death rate per population compared to other Gulf Co-operation Council (GCC) Countries. For Bahrain, the death rate per population was 8. UAE had a 10.9 death per population and Qatar had 15.2 mortality. While Oman and Saudi Arabia had the highest rate of deaths per population among other GCC countries with 27.4 and 25.4 mortalities respectively. During 2017, 428 deaths and 10219 injuries occurred due to traffic accidents in Kuwait. This requires a study that can provide a sufficient comprehension regarding traffic accidents especially because of the lack of similar studies that can provide similar perception for Kuwait traffic accidents.

Several factors can stimulate the occurrence of traffic accidents including meteorological, temporal, human factors. Alongside these factors, road characteristics can be considered to be another factor related to the occurrence of traffic accidents. A large number of researchers studied those different factors to identify the significant factors and their correlation with traffic accidents in different regions. In addition, road traffic accidents are classified into several types including rear-end collision, side-impact collision, sideswipe collision, dead on collisions, and rollover accidents. In this study, crashes in general including two or more vehicles involved in the accident, run-over, and rollover. First, drivers' behavior and their tendency to comply with traffic regulations and traffic accidents status were reviewed for the GCC region. Thereafter, run-over and roll over traffic accidents and their potential risk were presented.

In the Kingdom of Saudi Arabia, (Gharaibeh and Abu Abdo 2011) conducted a survey to understand whether youth had a sufficient knowledge regarding traffic safety and regulations. The area of the study was located to be at King Faisal University and the sample was comprised of male drivers only. The results showed that most of the participants were not complying with traffic laws and they were not using the seatbelt. Moreover, important traffic signs were had to be identified by the participants. One of the recommended solutions was aware the drivers about the traffic

regulations by TV programs. These programs should be disseminated for the people at an early age. Another research was conducted to determine the influence of using the seatbelt with respect to traffic accidents injuries and if drivers and front-seat passengers comply to the law of using the seatbelt in Saudi Arabia (Bendak 2005). The results were based on a questionnaire survey that was disseminated in two suburbs of Riyadh. Drivers complied more with traffic regulations regarding using the seatbelt than front-seat passengers. The number of injuries due to traffic accidents were decreased after the law was legislated.

(AL-REESI, et al. 2013) prepared a study to find the relationship between motorization rates, economic growth, and traffic accidents in Sultanate of Oman. The study's findings were based on the national data reported between 1985 and 2009 and by applying several methods to determine the relationships. The results showed that the increase in the economic growth of Oman, increased the rate of motorization which in turn increased traffic accidents and fatalities. (Bener 2005) conducted a study to evaluate the traffic accidents status in Qatar. Findings showed that most of the traffic accidents occurred due to drivers' careless behavior. Additionally, traffic accidents were ranked the third cause for mortalities in Qatar.

Rollover crashes are responsible for a high portion of fatalities compared to other crash types according to (NHTSA 2010), although their low percentage of occurrence. (Fréchède, et al. 2011) analyzed single-vehicle rollovers that occurred in three Australian states between 2000 and 2007. Rollover crashes were responsible for 35% of the fatalities. Also, they found that there is a significant relationship between crash type distribution and containment of the occupant and dense and urbanized states. Afterwards, (Chen, et al. 2016) studied the factors associated with rollovers and severities by employing classification and regression tree (CART) to identify the significant predictor and support vector machine (SVM) Gaussian radius basis function (RBF) models to evaluate the model performance by utilizing data that were gathered in New Mexico, USA. Results showed that alcohol or drug involvement, seatbelt use, number of travel lanes, driver demographic features, maximum vehicle damages in crashes, crash time, environmental conditions, and crash location were significant variables associated with causing fatalities and incapacitating injuries due to rollover crashes. Consistent with (Chen, et al. 2016), (Dabbour 2017) investigated the factors that were associated with rollover accidents risk for single-vehicle in North Carolina, USA by utilizing a logistic regression model. Dabbour found that vehicle age, speed limit exceeding, rural highways, curved highways, drivers who were younger than 21 years, fatigue, or other medical conditions, and when the light-duty vehicle involved in the collision is not a passenger car increased the risk of rollovers. Similar to the previous study, drunk drivers, or drivers who were influenced by illegal drugs also increased the risk of rollover accidents. According to the study's findings, the impacts of undivided highways, driver's gender, and adverse environmental conditions on increasing the risk of rollover accidents were not stable across the chosen time.

Consequently, this study aimed to identify whether the location of the traffic accident and the time when the crash happened are significant variables in Kuwait. Rollover, run-over, and other types of crashes were utilized in this study. Four out of six governorates of Kuwait that had the highest rate of traffic accidents were included: Kuwait City, Hawally, Al Farwaniya, and Al Ahmadi. The timeline for the accidents consisted of four years including 2013, 2014, 2016, and 2017. Thereafter, a multinomial logit regression model was applied to determine the correlation between the independent variables which they are the location of the accident and the year when the accident occurred with the dependent variable which is the type of accident.

The rest of the paper is organized as follows. Section 2 describes the data components and details. The multinomial logit regression model and its results were presented in section 3. Conclusions were presented in section 5.

2. Data Description

The data was obtained from General Department of Traffic that falls under Ministry of Interior of Kuwait. Four intervals time-line were included in this study which they are 2013, 2014, 2016, and 2017. 2015 was not included as the required data was not available. The data for the four years were collected in four different governorates: Kuwait City, Hawally, Al Farwaniya, and Al Ahmadi. A total of 287983 traffic accidents with only considering the three types of traffic accidents that occurred during the above-mentioned time-interval in all the four governorates. All these traffic accidents were considered in this study without excluding any case.

Table 1 is showing the three different traffic accidents types frequencies in the four locations and years. Hawally had the highest total of accidents compared to the other three governorates. While Kuwait City had the second highest crashes followed by Al Farwaniya, then Al Ahmadi. Noticeably, 242 run-over incidents happened in Al Farwaniya which was the highest number of run-overs. For the roll-overs, Al Ahmadi had the highest rate of roll-over accidents compared to other governorates with 484 roll-overs that occurred in the selected four-years. Observably, general

crashes and run-over accidents were higher in the year 2014 than the year 2013. Then, these types of accidents decreased in the following years 2016 and 2017. For rollovers, the accidents counts were almost steady but then decreased dramatically in the year 2017. Each location and year was assigned to a certain code so that it can be easily utilized later to perform the chosen model. Figure 1 showed all types of traffic accidents counts that occurred in the four governorates related to the four years that was chosen in this study. 2016 and 2017 had the lowest accidents counts in all governorates compared to previous years. In contrast, 2014 had higher traffic accidents that occurred in all four governorates. In all the four years, Hawally had the highest accidents rates.

Prior to applying the multinomial logit regression model, multicollinearity between the three independent variables was investigated. The average of variance inflation factor (VIF) was 1.001 which indicates that there was not a multicollinearity issue. As a result, the multinomial logit regression model was chosen in this study to identify the significant variables and determine the correlation between predictors and the dependent variable.

Table 1. Traffic accidents' types frequencies

	Abbreviation	Type of accident			Total	
		Crash	Run-over	Rollover		
Location	Kuwait City	LC1	88039	219	140	88398
	Hawally	LC2	91068	125	88	91281
	Al Farwaniya	LC3	58834	242	166	59242
	Al Ahmadi	LC4	48394	184	484	49062
Year	2013	YE1	77334	199	246	77779
	2014	YE2	86199	233	245	86677
	2016	YE3	62347	165	242	62754
	2017	YE4	60455	173	145	60773

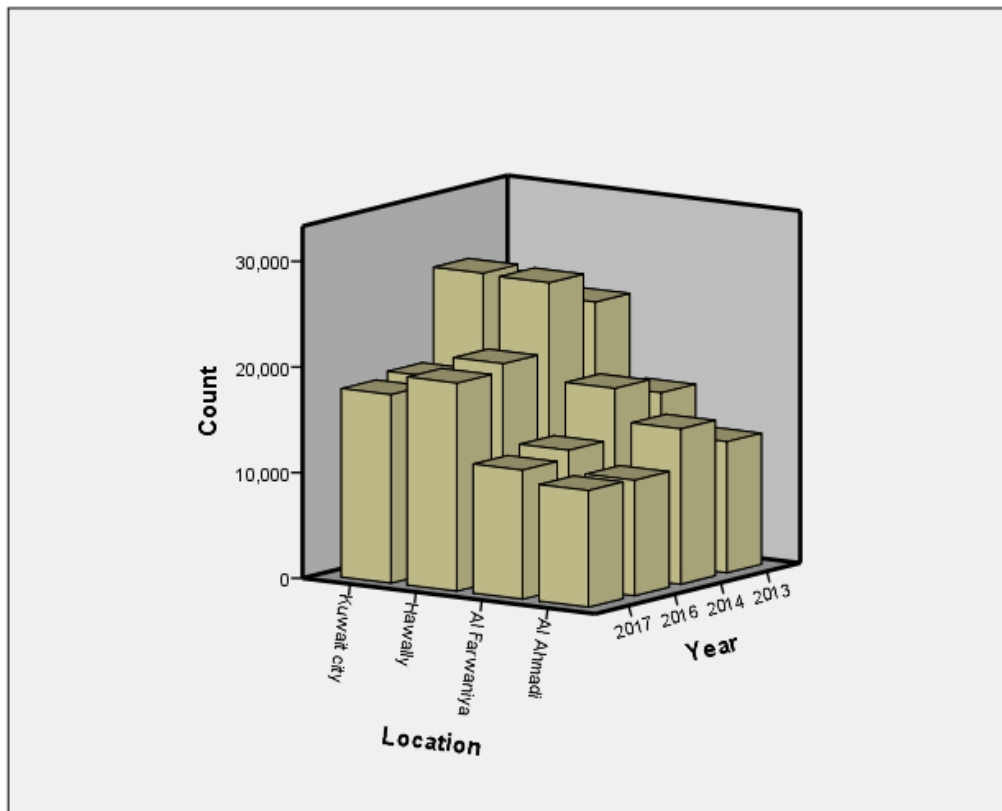


Figure 1. Accidents counts with respect to location and time

3. Methodology

3.1. Applied model

In this study, a multinomial logit regression model was chosen to identify the significant variables and determine the correlation between predictors and the dependent variable. A multinomial logit regression was chosen as this model is flexible compared to ordered model, it can handle various types of variables that consist more than two categories. Moreover, the multicollinearity test was performed to determine if there is an issue when applying this model as it can be affected by multicollinearity between the independent variables. The test showed that there was no multicollinearity issue.

By following previous proceedings in applying the multinomial logit regression model (Ma, et al. 2014), the type of accident that represents the dependent variable and that includes crashes, run-over, and rollover accidents was assigned to be y and crashes was assigned to be $y=1$, run-over accidents was assigned to be $y=2$, and rollover was assigned to be $y=3$ which is the reference level. Then $y=1$ and $y=2$ were compared to $y=3$. The $y=1$ and $y=2$ logit regression functions were as followed:

$$\text{logit}(p_1) = \ln \left(\frac{p(y = 1|x)}{p(y = 3|x)} \right) = \alpha_1 + \sum_{i=1}^m \beta_{1i} x_i \quad (1)$$

$$\text{logit}(p_2) = \ln \left(\frac{p(y = 2|x)}{p(y = 3|x)} \right) = \alpha_2 + \sum_{i=1}^m \beta_{2i} x_i \quad (2)$$

For both (1) and (2) equations, the value for the i th independent variable is x_i , α_1 and α_2 represented the intercept of the first and the second logit function respectively, the number variables in both equations (1) and (2) was represented by m . β_1 and β_2 represented the corresponding coefficient of the first and the second logit function respectively.

The condition probability of k th outcome category was:

$$p(y = k|x) = \frac{\exp(\alpha_k + \sum_{i=1}^m \beta_{ki} x_i)}{1 + \sum_{k=1}^{K-1} (\alpha_k + \sum_{i=1}^m \beta_{ki} x_i)} \quad (3)$$

α_K is the intercept of the k th logit function, the corresponding coefficient of the k th logit function (3) is β_{ki} , and the number of outcome category is K .

3.2. Results

Table 2 showed the maximum likelihood for the independent variables. As shown in table 2, both the location where the accident happened and the year when the accident occurred were significant variables as their p-value were less than 0.05. As a result, both predictors were included in the final multinomial logit regression model to determine the correlations.

Table 2. Maximum likelihood analysis

Independent variables	Abbreviation	-2 Log Likelihood of Reduced Model	Chi-Square	Degree of freedom	P-value
Location	LC	1062.102	858.132	6	0.000
Year	YE	230.820	26.851	6	0.000

Table 3 showed the results of the applied the multinomial logit regression. As previously mentioned, rollover accidents were chosen to be the reference to investigate if there is a relationship of the location and time with the accident types. Crashes were compared to rollovers in the first set of table 3, then run over was compared to rollovers. LC1, LC2, and LC3 that represented Kuwait City, Hawally, and Al Farwaniya respectively were significant in the first and second

set with positive coefficients and the reference level was Al Ahmadi governorate. This indicated that Al Ahmadi governorate had a higher probability to have rollover accidents compared to the three other governorates. For the time when the accident occurred, YE1 and YE3 that represented 2013 and 2016 were significant in the first and second set with negative coefficients compared to the reference level which was 2017. This indicated that the year 2017 had a higher probability to have run-over compared to the two other years 2013 and 2016.

Table 3. Multinomial logit model for traffic accidents types

Variable	Coefficient	Standard Error	Wald Chi-Square test	P - value	Odds ratio
Y=1 (crashes vs rollover)					
Intercept	4.876	0.088	3056.081	0.000	
LC1	1.842	0.096	366.914	0.000	6.311
LC2	2.341	0.116	406.955	0.000	10.389
LC3	1.271	0.090	198.550	0.000	3.563
YE1	-0.337	0.105	10.319	0.001	0.714
YE3	-0.501	0.105	22.591	0.000	0.606
Y=2 (run-over vs rollover)					
Intercept	-0.635	0.132	23.054	0.000	
LC1	1.421	0.139	104.947	0.000	4.139
LC2	1.323	0.164	65.148	0.000	3.755
LC3	1.352	0.133	103.390	0.000	3.863
YE1	-0.444	0.148	9.025	0.003	0.642
YE3	-0.578	0.151	14.591	0.000	0.561

4. Conclusions

This study was conducted to investigate the impacts of both location and time on three types of traffic accidents that occurred in Kuwait by utilizing official traffic accidents data that were collected from General Department of Traffic. Four governorates and years were included to distinguish the differences between them with respect to traffic accidents that resulted in 287983 crashes, rollovers, and run-over accidents.

The statistics showed that the accidents decreased through the four years. In addition, governorate the had the higher rate of traffic accidents during the selected years was identified which was Hawally. For the rollover accidents, Al Ahmadi was recognized as the governorate that had the highest rollovers accidents compared to other governorates. Run-over accidents were significantly higher in Al Farwaniya governorate. Afterward, a multinomial logit regression was applied to identify the significant predictors and determine the correlation between independent variables and the dependent variable. The results showed that both the location and time were significant variables related to traffic accidents types occurrence. The applied model confirmed that Al Ahmadi governorate had a higher probability of having rollover accidents compared to other governorates. Moreover, 2017 had higher odds of having run-over accidents compared to the other three selected years.

All in all, this study can be considered as a baseline for future studies that concern with traffic accidents in Kuwait due to the lack of similar studies. This study can help policy-makers, related institutions, police departments and ministry of interior in locating the area that is correlated with the three traffic accidents types. Additionally, this study can help in evaluating the newly established rules regarding mitigating and lessening traffic accidents through the selected time-period and locations in Kuwait.

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Biographies

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Ahmad Aiash holds a BSc in civil engineering, and currently a MSc candidate in civil engineering at Kuwait University, Kuwait. He is working as a research assistant and part of the transportation research team in Kuwait University to study existing Traffic, Highway, and related transport problems. His research intersects cover different aspect of traffic safety data analytics in GCC and Kuwait using data mining techniques, advanced regression analysis, geographic information systems, artificial intelligence, risk assessment & management and behavior analysis techniques.