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Traffic Accidents Prediction Models to Improve Traffic Safety in Greater Amman Area

Mohammad Abojaradeh*, Ph.D., P.E.
Faculty of Engineering, Department of Civil Engineering, Zarqa University
P.O. Box 2000, Zarqa 13110, Jordan Tel: 00962-5-3821100
*E-mail: abojaradeh@yahoo.com

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Abstract
Highway related accidents are considered one of the most serious problems in the modern world. Traffic accidents cause serious threat to human life worldwide. According to the World Health Organization (WHO), more than 1.2 million people die each year in motor vehicle accidents and more than 50 millions are injured each year worldwide. Jordan, as one of the developing countries, has high level of traffic accidents. In Jordan, traffic accidents have caused more than 13000 fatalities between the years 1989-2012.
The main objectives of this study are: to develop traffic accidents regression prediction models in Amman Greater Area. These models relate accident numbers, as a dependent variable, with possible causes of accidents that are related to driver behavior, as independent variables. Also, to propose effective countermeasures to reduce the frequency and severity of traffic accidents in Jordan.
Accident data were collected from the General Security Directorate and from the Jordan Traffic Institute for the selected areas inside Greater Amman Area in Jordan. These data were analyzed and used in the regression models. Several regression prediction models were formed and the best models were chosen. The intersections and road segments, under this study, were arranged according to the traffic accidents severity. The most dangerous and hazardous streets and intersections were located in the study areas. Proper treatments and improvements are needed to reduce the number and severity of accidents in these areas. Preventive countermeasures were recommended to enhance traffic safety in Jordan specially Amman Area.
Key Words: Traffic Accidents, Traffic Safety, Driver Behavior, Countermeasures, Regression Models, Jordan Traffic Institute.

1. Introduction

Highway related accidents are considered one of the most serious problems in the modern world. Traffic accidents cause serious threat to human life worldwide. Every year, traffic crashes claim more people lives than drugs, guns, suicide, and any other fatal diseases combined. Traffic accidents increase as the number of motor vehicles increase through out the world. According to the World Health Organization (WHO), more than 1,200,000 people die each year in motor vehicle accidents and more than 50 millions are injured each year worldwide (WHO 2010). In many countries, such as the United States (USA), motor vehicle crashes are the leading cause of death for people between the ages of 1 to 34 years (NHTSA 2010, DOT 2010, FHWA 2010). Traffic engineers are working to ensure that the highway system is designed and operated such that accident rates and severity can be reduced. Enforcement, education, and engineering are called the 3E's factors to ensure that traffic accidents can be reduced. Motorists are encouraged to drive defensively and to understand and obey traffic regulations and rules (Abojaradeh 2012).

Traffic Accident or crash is defined as a random event or an occurrence involving one or more motor vehicles in a collision that results in property damage, injury, or death (Wikipedia 2012, Garber 2010).
Traffic crashes and collisions could be prevented, and its effects can be minimized by modifying driver behavior, vehicle design, roadway geometry, and by modifying the traveling environment. If the factors that have contributed to any traffic accident are identified, it is then possible to modify and improve the highway system. A safer highway system is likely to result with the reduction or elimination of crash causing factors (Ismeik 2010, Jrew 2012, Abojaradeh 2012).
There are many causes for accidents. The human factor, the driver, is the primary cause of those accidents. The main cause of traffic accidents is disobeying the traffic safety laws, which include speeding, driver distraction, driving under the influence of drugs or alcohol, close following between the running cars, yielding for pedestrians and other vehicles etc. The causes of crashes are usually complex and involve several factors. The main factors can be divided

into four separate categories: the driver, the vehicle, the roadway, and the environment (Garber 2010, Abojaradeh 2012).
It is necessary to collect data regarding the frequency and severity of crashes at specific locations. Also, it is important to evaluate the success or failure of any highway improvement (Ismeik 2010, Aloush 2008, Jrew 2007).
The federal Highway Administration (FHWA) in the USA has developed the Highway Safety Improvement Program (HSIP) in order to achieve two main objectives (FHWA 2010, Garber 2010):

1. Reducing the number and severity of crashes.
2. Decreasing the potential for crashes on all highways.

The HSIP consists of three components: planning, implementation, and evaluation. The planning component of the HSIP consists of four processes:

1. Collecting and maintaining data.
2. Identifying hazardous locations
3. Conducting engineering studies.
4. Establishing project priorities.

Crash data are usually obtained from local transportation and police agencies. All relevant information is usually recorded by the police on an accident report form. Each item of information on the accident report form is coded and stored in a computer file to form national data bank. Retrieval of any stored data in the data bank requires only the input of appropriate commands into the computer for any specific data required, and those data are given as output or printed out. Crash data can be summarized according to type, severity, contributing circumstances, environmental conditions, and time periods. Then, traffic crash data are analyzed for the following reasons:

1. To identify patterns that may exist.
2. To determine the possible causes with respect to drivers, roadways, and vehicles.
3. To develop countermeasures that will reduce the rate and severity of future crashes.

Identifying hazardous locations is a very important process. Hazardous locations are sites where crash rates frequencies, calculated on the basis of the same exposure data, are higher than the expected value for other similar locations. A detailed engineering study is performed for the hazardous locations to identify the safety problem so that suitable safety related countermeasures can be developed.
Engineering studies include an in-depth study of the crash data obtained at the hazardous site, and a field review of the study site. That is done to identify the safety deficiencies at the study site, and then to develop alternative counter measures to alleviate the identified safety deficiencies.
The final process in planning component is to establish project priorities by conducting economies analysis in order to determine the economic feasibility of each set of countermeasures and to determine the best alternative among mutually exclusive countermeasures.
The next step in the HSIP components is the implementation of the selected proposal. The final step is the evaluation of the effectiveness of the highway safety improvement by conducting before and after study (Garber 2010).

1.1 Traffic Safety in Jordan

Highways traffic safety is one of the major problems in Jordan. Jordan, as one of the developing countries, has high level of traffic accidents. In Jordan, traffic accidents have caused more than 13000 fatalities between the years 1989-2012 (JTI 2012, PSD 2010). The economical and industrial rise that spread rapidly all over the country in the past recent years directly contributed in this problem. The number of cars rapidly increased, that led to directly increasing accident frequency and severity. Every year especially in the summer many tourists and Jordanians come to the country causing an overload on the traffic services offered on inner and outer city roads. That itself causes a rapid increase in fatal accidents and serious economical and social and health related issues (PSD 2010, JTI 2010).
Jordan is considered one of the leading countries in their yearly accidents rates. The average world fatality rate per 10000 vehicles is equal to 19. The modern country fatality rate is equal to 2. The fatality rate in Jordan was above 13 fatalities/ 10000 vehicles in the past 10 years from 1995-2004 as shown in Figure 1. Fatality rate has decreased to 6.2 fatalities/ 10000 vehicles in 2010. Annual accident cost in Jordan is more than 250 thousands JD which represents more than 2.4 % of the Grand Domestic Product (GDP) as shown in Table 1. Some statistics data of population,

number of vehicles, accident frequency and severity growth between the years 2001-2010 are presented in Table 1 (JTI 2010, PSD 2010, DGS 2010).

Special concerns must be focused on pedestrian safety. In a previous study for the author about evaluation of pedestrian bridges and pedestrian safety in Jordan, it was concluded that pedestrian bridges have a positive impact and have great potential of reducing number of pedestrian fatalities. Also, it was concluded that the main factors that affecting the use of pedestrian bridges are: the posted speed limit, the overall width of the cross walkway, and the existence of median barrier (Abojaradeh 2013).

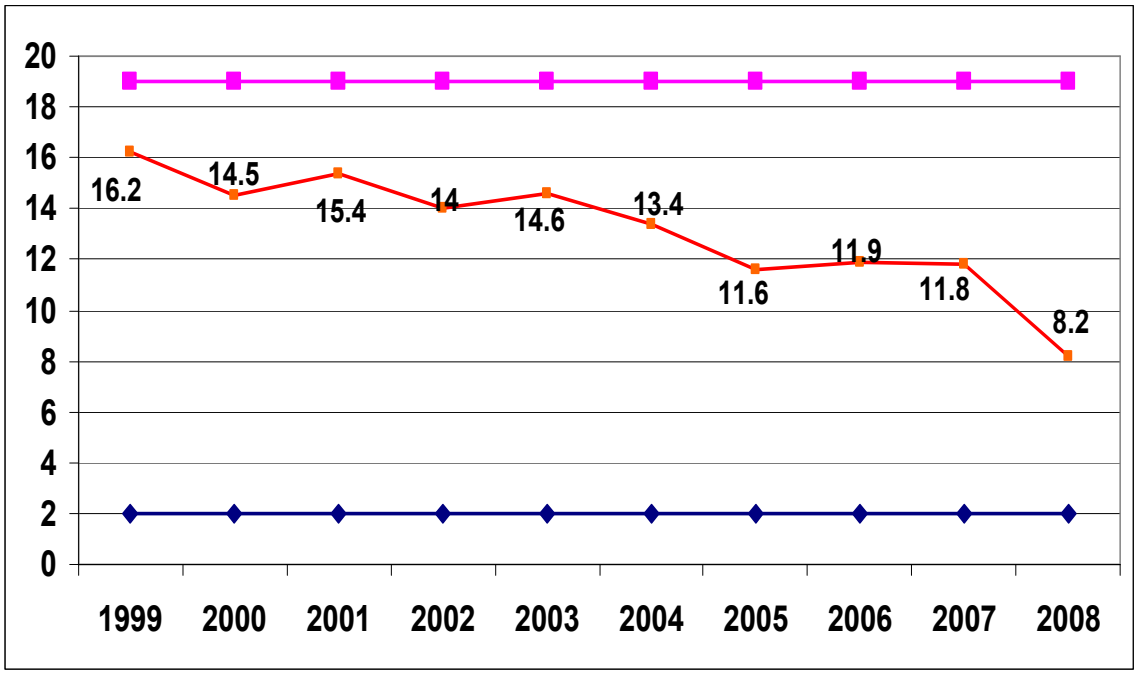

Figure 1. Traffic Accidents Fatality Rate per 10000 Vehicles in Jordan (Middle Line) Compared with the World Average (Upper Line) and the Modern Countries (Lower Line). (Source: Jordan Traffic Institute JTI)

Table 1. Statistics Data for Population, Vehicles and Accident in Jordan between the Years 2001-2010 (Source: Jordan Traffic Institute)

Year	Population Thousands	Vehicles	Accidents	Injuries	Fatalities	Cost Million JD
2001	5153	509832	52662	18832	783	150
2002	5307	535112	52913	17381	758	170
2003	5325	568096	62115	18368	832	190
2004	5350	614614	70266	16727	818	202
2005	5473	679731	83129	17579	790	220
2006	5600	755477	98055	18019	899	258
2007	5723	841933	110630	17969	992	281
2008	5867	905592	101066	13913	740	245
2009	5980	994753	122793	13913	676	258
2010	6113	1075453	140014	15662	670	311

2. Research Objectives

The main objectives of this study are:

1. To analyze the traffic accidents and their main causes that occurred on some of the major streets and intersections inside Greater Amman Municipality.

2. To study the effect of drivers behavior mistakes on the traffic accidents number and severity.
3. To determine and build prediction statistical regression models, which relates the number of accidents (dependent variable), with drivers' behavior mistakes (independent variable) by using the Statistical Package for Social Sciences (SPSS) software.
4. To determine the black points or the most Hazardous and dangerous locations inside the study area. This procedure can be done by comparing the actual number of accidents on each location with the predicted numbers of accidents by using the predicted regression model from the SPSS Software.
5. To find the best countermeasures and solutions and apply these solutions on the most dangerous locations in order to reduce the number and severity of traffic accidents on these locations.

3. Study Area

This study focuses on major streets and intersections in five main areas in Greater Amman Municipality. The study area includes the following areas: Marj Al-Hamam in Western Amman and Abu Nusair, and Suweileh in North Amman, Jubeeha in Middle Amman, and Marka in Eastern Amman. A total number of accidents of 6901 were analyzed in the study area.

4. Methodology

4.1 Traffic Accident Data Collection and Organization

Traffic Accident Data were collected from the General Security Department and from Jordan Traffic Institute for the years 2004-2011. Data were organized in statistical tables, charts, and figures and prepared in order to represent data in an easy and illustrative manner.

4.2 Analysis of Traffic Accident Data

These accident data were analyzed and used in the predicted regression models. Several regression prediction models were formed and the best models were chosen. The intersections and road segments, under this study, were arranged according to the traffic accidents severity. Preventive countermeasures were recommended to enhance traffic safety in Jordan specially Amman Area.

The main causes for traffic accidents and the top driver behavior mistakes that should be avoided by drivers were determined. The main focus in this study is to resolve this serious problem that is threatening our people lives, and causing major economical and social concerns in this country. It is recommended to widen the study area and to do a comprehensive study for most areas in Greater Amman Area.

4.3 Statistical Model Formation

SPSS (Statistical Package for Social Sciences) software was used in forming the Regression Models in this study. SPSS is considered one of the most frequently used program for researchers in many fields such as engineering, science, art, education, and psychology (SPSS 2009).

The method of least squares that leads to the best fitting line of a postulated form to a set of data is used to form Regression Models between the dependent variable Yi, and independent variables Xi. In this study, the dependent variable Yi includes accident frequency, injuries, and fatalities. On the other hand, the independent variable Xi includes the drivers' behavior mistakes which caused traffic accidents. The detailed drivers' mistakes are shown in Table 2. The total numbers of accidents in the study area caused by drivers' behavior mistakes are shown in Table 3.

A relationship between the dependent and the independent variables of the form

$$Y_i = ß_0 + ß_1X_1 + ß_2X_2 + \ldots + ß_n X_n$$

It was calibrated by the method of least squares. This relationship is known as a multiple linear regression model.

Table 2. Drivers Behavior Mistakes Which Contributed To Traffic Accidents

Variables	Drivers Mistakes (Independent Variables)
X1	Close following (not enough safe gap)
X2	Lanes violation
X3	Wrong passing
X4	Wrong turning
X5	Sudden turning
X6	Wrong u-turning
X7	Wrong backing
X8	Distraction and not taking enough precautions
X9	Yield violation (Not respecting priorities of vehicles)
X10	Pedestrian yield violation (Not respecting the rights of way for pedestrians)
X11	Wrong way driving
X12	Speeding (violation of speed limit)
X13	Violation of traffic signs
X14	Brake system failure
X15	Not securing the car when stopping
X16	Running on the red light
X17	Not securing the vehicle loads

Table 3. Total Traffic Accidents Because of Drivers' Behavior Mistakes for All the Streets and Intersections in the Study Area

Variable	Abu Nuseer 2004	Abu Nuseer 2005	Marj Al-Hamam 2004	Marj Al-Hamam 2005	Suweileh 2004	Al-Jubeeha 2004	Marka 2005	Total
Y1	448	94	866	181	1557	2355	1400	6901
X1	130	7	241	12	397	966	291	2044
X2	70	20	225	52	257	266	189	1079
X3	2	1	37	0	10	13	6	69
X4	3	3	5	3	10	32	5	61
X5	48	9	105	32	163	225	225	807
X6	11	0	8	1	0	7	9	36
X7	46	3	68	1	96	90	87	391
X8	17	15	24	44	385	431	380	1296
X9	63	7	101	13	152	193	118	647
X10	24	15	12	6	44	46	32	179
X11	4	2	1	2	0	0	4	13
X12	10	8	14	7	13	23	10	85
X13	12	0	7	0	21	47	2	89
X14	2	0	4	0	3	2	11	22
X15	4	0	12	1	1	13	14	45
X16	2	4	2	7	4	1	15	35
X17	0	0	0	0	1	0	2	3

4.4 Interpretation and Selection of the Best Regression Model

Stepwise calibration procedure was used to form the Multiple Linear Regression Model. The selections of explanatory variables follow the following four guidelines to decide which explanatory (independent) variables to include in the linear regression model. The selected independent variable has to follow the following four rules:

1. Must be linearly related to the dependent variable.
2. Must be highly correlated with the dependent variable.
3. Must not be highly correlated between themselves.
4. Must lend themselves to relatively easy projection

The selected regression model has to have maximum 3 to 4 variables in order to have an easy projection and application, and in order to have a lower cost. Also, the selected regression model should have strong coefficient of determination R^2 value (Montgomery 2010).

The coefficient of determination R^2, quantifies the fact that the goodness of fit of a regression line increases with the proportion of the total variation that is explained by the regression line. R^2 ranges from zero when none of the total variation is explained by the regression line to unity when all of the variation is explained by the line. It is denoted as a squared quantity to capture the fact that it is always non negative. The square root of R^2 the Coefficient of determination is called the coefficient of correlation (r or R). Its value can range from -1 to 1. In the case of linear regression the sign of R is the same as the sign of the slope of the regression line. When R is near 1, there is a high positive correlation between x and y. when R is near -1, there is a high negative correlation. If R is around zero, then there is no correlation between x and y (Papacostas 2008, Montgomery 2010).

5. Results and Analysis

5.1 Prediction Regression Models for All the Streets in the Study Area

The dependent variables Yi include the following:
Y1 = number of accidents
Y2 = number of injuries
Y3 = number of fatalities
The independent variables Xi include all drivers' behavior mistakes which contributed to the traffic accidents. All these variables are shown in Tables 2 and 3.

5.1.1 Regression Models between the Total Number of Accidents Y1 and the Independent Variables for All the Streets in the Study Area.

A sample of the SPSS software output are shown in Tables 4, 5, and 6.
Model number 3 was selected as shown below. This model relates the number of accidents with the following independent variables:
X1 = Close following (not enough safe gap)
X2 = Lanes violation
X8 = Distraction and not taking enough precautions

Model No.	Regression Model	Adjusted R^2
3	$Y_1=9.563+1.193X_1+1.99X_2+1.038X_8$	0.984

The chosen model is a strong model with R^2 of 0.984. That main 98.4% of the total number of accidents are explained by X1, X2, and X8. The relationship between the dependent variable and the independent variables is directly proportioned as expected. A close look to Table 3 shows that X1, X2, and X8 are the main causes of accidents in the study area with values of 2044, 1079, and 1296 respectively. Also, the highest percentages of the main causes of traffic accidents are X8, X1, and X2 with values of 21.9%, 17.4%, and 13.2% respectively as shown in Table 7.

Table 4. Descriptive Statistics for All Variables for Accident Data for All Streets

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Y1	**96**	**1.00**	**536.00**	**67.3542**	**98.46912**
X1	**96**	**.00**	**286.00**	**20.1979**	**43.19396**
X2	**96**	**.00**	**146.00**	**10.5104**	**18.79641**
X3	**96**	**.00**	**30.00**	**.7083**	**3.14866**
X4	**96**	**.00**	**6.00**	**.6146**	**1.28448**
X5	**96**	**.00**	**86.00**	**7.0104**	**12.48198**
X6	**96**	**.00**	**56.00**	**1.2396**	**5.99604**
X7	**96**	**.00**	**40.00**	**3.8021**	**5.77949**
X8	**96**	**.00**	**116.00**	**12.3021**	**20.66022**
X9	**96**	**.00**	**37.00**	**6.2812**	**8.27896**
X10	**96**	**.00**	**17.00**	**1.7917**	**2.64741**
X11	**96**	**.00**	**4.00**	**.1354**	**.51544**
X12	**96**	**.00**	**7.00**	**.8333**	**1.48442**
X13	**96**	**.00**	**16.00**	**.8333**	**2.18447**
X14	**96**	**.00**	**4.00**	**.1667**	**.55567**
X15	**96**	**.00**	**6.00**	**.4167**	**.94776**
X16	**96**	**.00**	**1.00**	**.0208**	**.14358**
X17	**96**	**.00**	**4.00**	**.0625**	**.43073**
Valid N (list wise)	**96**				

Table 5. Coefficient of Determination R^2 and R Values for All Models for Accident Data for All Streets

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.942[a]	.887	.886	33.24756
2	.985[b]	.970	.969	17.34966
3	.992[c]	.985	.984	12.35269
4	.997[d]	.994	.994	7.69414
5	.998[e]	.995	.995	7.00730
6	.998[f]	.996	.996	6.43537
7	.999[g]	.998	.998	4.61765
8	.999[h]	.999	.999	3.47799
9	1.000[i]	.999	.999	2.97427
10	1.000[j]	1.000	1.000	2.15666
11	1.000[k]	1.000	1.000	1.91787
12	1.000[l]	1.000	1.000	1.70265
13	1.000[m]	1.000	1.000	1.57798
14	1.000[n]	1.000	1.000	1.44900
15	1.000[o]	1.000	1.000	1.37284
16	1.000[p]	1.000	1.000	1.33679

a. Predictors: (Constant), x1

b. Predictors: (Constant), x1, x2

c. Predictors: (Constant), x1, x2, x8

d. Predictors: (Constant), x1, x2, x8, x9

e. Predictors: (Constant), x1, x2, x8, x9, x3

f. Predictors: (Constant), x1, x2, x8, x9, x3, x6

g. Predictors: (Constant), x1, x2, x8, x9, x3, x6, x5

h. Predictors: (Constant), x1, x2, x8, x9, x3, x6, x5, x7

i. Predictors: (Constant), x1, x2, x8, x9, x3, x6, x5, x7, x13

j. Predictors: (Constant), x1, x2, x8, x9, x3, x6, x5, x7, x13, x10

k. Predictors: (Constant), x1, x2, x8, x9, x3, x6, x5, x7, x13, x10, x12

l. Predictors: (Constant), x1, x2, x8, x9, x3, x6, x5, x7, x13, x10, x12, x4

m. Predictors: (Constant), x1, x2, x8, x9, x3, x6, x5, x7, x13, x10, x12, x4, x11

Table 6. Coefficients for All Regression Models for All Streets

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	23.984	3.750		6.396	.000
	x1	2.147	.079	.942	27.190	.000
2	(Constant)	14.346	2.049		7.003	.000
	x1	1.618	.053	.710	30.520	.000
	x2	1.934	.122	.369	15.881	.000
3	(Constant)	9.563	1.542		6.202	.000
	x1	1.193	.058	.524	20.487	.000
	x2	1.990	.087	.380	22.896	.000
	x8	1.038	.109	.218	9.563	.000
4	(Constant)	4.548	1.046		4.347	.000
	x1	1.095	.037	.480	29.446	.000
	x2	1.685	.060	.322	28.191	.000
	x8	1.084	.068	.227	16.008	.000
	x9	1.536	.127	.129	12.089	.000
5	(Constant)	4.179	.956		4.369	.000
	x1	1.059	.035	.464	30.403	.000
	x2	1.671	.055	.319	30.646	.000
	x8	1.171	.065	.246	18.097	.000
	x9	1.438	.118	.121	12.206	.000
	x3	1.121	.252	.036	4.440	.000

6	(Constant)	4.141	.878		4.714	.000
	x1	1.079	.032	.473	33.365	.000
	x2	1.627	.051	.311	31.837	.000
	x8	1.117	.061	.234	18.379	.000
	x9	1.460	.108	.123	13.476	.000
	x3	1.139	.232	.036	4.910	.000
	x6	.491	.117	.030	4.208	.000

a. Dependent Variable: y

Table 7. Percentage of Drivers' Behavior Mistakes in the Years 2001-2005 (Source: JTI and PSD).

Drivers Mistakes	2001	2002	2003	2004	2005
Wrong way Driving	0.2	0.3	0.3	0.3	0.3
Wrong passing	1.2	1.2	1.0	0.9	0.9
Speeding	4.0	3.4	3.0	2.4	1.9
Lanes violation	17.9	22.4	15.0	14.2	13.2
Wrong turning	2.9	0.4	0.5	1.0	0.7
Wrong u-turning	1.5	1.4	0.5	0.4	0.2
Driving under the influence DUI	0.2	0.0	0.0	0.0	0.0
Close following	17.9	21.7	19.4	17.7	17.4
Overloading	0.2	0.3	0.1	0.1	0.0
Wrong stopping	0.6	0.3	0.3	0.4	0.5
Running on the red light	1.0	1.1	1.1	0.8	0.8
Violating of the traffic signs	5.3	8.2	4.3	6.4	3.0
Yield violation right of way of vehicles	9.1	0.8	8.4	10.0	13.8
Pedestrian yield violation Right of way for pedestrians	3.3	7.7	4.4	3.0	1.8
Wrong backing	5.5	6.9	7.3	8.0	8.4
Distraction and not taking enough precautions	1.1	0.3	1.6	6.4	21.9

Table 8. Rank of the Hazardous Streets in the Study Area

Rank	Street Name	Location Area	Actual Accidents	Predicted Accidents	Difference
1	Khalil Alsaket St.	Al-Jubeeha	176	136	40
2	Main St. of Marj Alhamam	Marj Al-Hamam	234	195	39
3	Abu-Usair St.	Abu USAir	175	137	38
4	Alewife St.	Al-Jubeeha	101	70	31
5	Shafer Badran St.	Abu Nusair	85	59	26
6	Jafar Ben Abee Taleb St.	Marka	50	27	23
7	Abdullah St. from Iskan Bank to the Industrial Area	Marka	73	54	19
8	Yagooz St.	Al-Jubeeha	112	94	18

9	**Aljaysh St. From Pepsi Bridge to Marka Bridge**	**Marka**	**271**	**253**	**18**
10	**Uhud St.**	**Suweileh**	**38**	**22**	**16**
11	**Abdullah St. from Altarkhees to Marka Bridge**	**Marka**	**65**	**51**	**14**
12	**Altarawneh St.**	**Al-Jubeeha**	**123**	**111**	**12**
13	**Fatima Alzahra St.**	**Marka**	**55**	**44**	**11**
14	**Princess Taghreed St.**	**Marj Al-Hamam**	**68**	**57**	**11**

5.1.2 Determination of Hazardous Locations and Treatment Priority for all Streets in the Study Area

The next step is to determine the black points or the most Hazardous and dangerous locations for all the streets inside the study area. This step was done by comparing the actual number of accidents on each location with the predicted numbers of accidents by using the predicted regression model from the SPSS Software. The difference between the actual number accidents and the predicted number of accidents are calculated. Then, the results are sorted at descending order. The street with the highest difference value is considered as the most hazardous location and is given the priority in the suggested treatment. The results of applying model 3 are shown in Table 8. The top 3 most dangerous locations in the study area are (as shown in Table 8):

1- Khali Al-Sakit Street in Al-Jubeeha
2- Main Street of Marj Al-Hamam in Marj Al-Hamam
3- Abu Nusair Street in Abu Nusair

5.1.3 Regression Models between the Total Number of Injuries Y2 and the Independent Variables for all the Streets in the Study Area.

Model number 3 was selected as shown below. This model relates the number of accidents with the following independent variables:

X2 = Lanes violation
X6 = Wrong u-turning
X5 = Sudden turning

Model No.	Regression Model	Adjusted R^2
3	$Y_2=4.637+0.62X_2+1.272X_6+0.813X_5$	**0.71**

The chosen model is a fair model with R^2 of 0.71. That main 71% of the total number of injuries because of accidents are explained by X2, X6, and X5. The relationship between the dependent variable and the independent variables is directly proportioned as expected.

5.1.4 Determination of Hazardous Locations and Treatment Priority for all Streets in the Study Area

The next step is to determine the black points or the most Hazardous and dangerous locations for all the streets inside the study area. This step was done by comparing the actual number of injuries on each location with the predicted numbers of injuries by using the predicted regression model from the SPSS Software. The difference between the actual number injuries and the predicted number of injuries are calculated. Then, the results are sorted at descending order. The street with the highest difference value is considered as the most hazardous location and is given the priority in the suggested treatment. The top 3 most dangerous locations in the study area are:

1- Airport Street in Marj Al-Hamam
2- Main Street of Marj Al-Hamam in Marj Al-Hamam
3- Al-Shaheed Street in Al-Jubeeha

5.1.5 Regression Models between the Total Number of Fatalities Y3 and the Independent Variables for all the Streets in the Study Area.

Model number 2 was selected as shown below. This model relates the number of accidents with the following independent variables:
X6 = Wrong u-turning
X5 = Sudden turning

Model No.	Regression Model	Adjusted R^2
2	$Y_3=0.029+0.148X_6+0.065X_5$	0.573

The chosen model is a fair model with R^2 of 0.573. That main 57.3% of the total number of injuries because of accidents are explained by X6, and X5. The relationship between the dependent variable and the independent variables is directly proportioned as expected.

5.1.6 Determination of Hazardous Locations and Treatment Priority for all Streets in the Study Area.
The next step is to determine the black points or the most Hazardous and dangerous locations for all the streets inside the study area. This step was done by comparing the actual number of fatalities on each location with the predicted numbers of fatalities by using the predicted regression model from the SPSS Software. The difference between the actual number fatalities and the predicted number of fatalities are calculated. Then, the results are sorted at descending order. The street with the highest difference value is considered as the most hazardous location and is given the priority in the suggested treatment. The top 3 most dangerous locations in the study area are:

1. Airport Street in Marj Al-Hamam
2. Al-Hizam Street in Marka
3. Al-Jeysh Street from Pepsi Bridge to Marka Bridge in Marka

5.2 Prediction Regression Models for all the Signalized Intersections in the Study Areas.

5.2.1. Regression Models between the Total Number of Accidents Y1 and the Independent Variables for all the Signalized Intersections in the Study Area.

The same procedure was followed. Model number 2 was selected as shown below. This model relates the number of accidents with the following independent variables:
X8 = Distraction and not taking enough precautions
X1 = Close following (not enough safe gap)

Model No.	Regression Model	Adjusted R^2
2	$Y_1=4.064+1.225X_8+1.565X_1$	0.946

The chosen model is a strong model with R^2 of 0.946. That main 94.6% of the total number of accidents are explained by X8 and X1. The relationship between the dependent variable and the independent variables is directly proportioned as expected.

5.2.2 Determination of Hazardous Locations and Treatment Priority for all Signalized Intersections in the Study Area

The next step is to determine the black points or the most Hazardous and dangerous locations for all the signalized intersections inside the study area. This step was done by comparing the actual number of accidents on each location with the predicted numbers of accidents by using the predicted regression model from the SPSS Software. The difference between the actual number accidents and the predicted number of accidents are calculated. Then, the results are sorted at descending order. The signalized intersection with the highest difference value is considered as the most hazardous location and is given the priority in the suggested treatment. The top 3 most dangerous locations in the study area are:

1- Abu Nusair signalized intersection in Abu Nusair

2- Ein Ghazal signalized intersection in Marka
3- Eskan Alia signalized intersection in Marj Al-Hamam

5.3 Prediction Regression Models for all the Un-Signalized Intersections in the Study Areas.

5.3.1 Regression Models between the Total Number of Accidents Y1 and the Independent Variables for all the Un-Signalized Intersections in the Study Area.

The same procedure was followed. Model number 2 was selected as shown below. This model relates the number of accidents with the following independent variables:
X9 = Yield violation (Not respecting priorities of vehicles)
X1 = Close following (not enough safe gap)

Model No.	Regression Model	Adjusted R^2
2	**$Y_1=1.452+2.207X_9+1.007X_1$**	**0.988**

The chosen model is a strong model with R^2 of 0.988. That main 98.8% of the total number of accidents are explained by X9 and X1. The relationship between the dependent variable and the independent variables is directly proportioned as expected.

5.3.2 Determination of Hazardous Locations and Treatment Priority for all Un-Signalized Intersections in the Study Area

The next step is to determine the black points or the most Hazardous and dangerous locations for all the un-signalized intersections inside the study area. This step was done by comparing the actual number of accidents on each location with the predicted numbers of accidents by using the predicted regression model from the SPSS Software. The difference between the actual number accidents and the predicted number of accidents are calculated. Then, the results are sorted at descending order. The un-signalized intersection with the highest difference value is considered as the most hazardous location and is given the priority in the suggested treatment. The top 3 most dangerous locations in the study area are:

1- Shafa Badran Circle in Abu Nusair
2- Al-Dala circle in Marj Al-Hamam
3- Tab Kra circle in Abu Nusair

6. Summary and Conclusions:

The following conclusions are withdrawn from this study:
1. The main causes of traffic accidents in all streets in the study area are:
a. Close following (not enough safe gap)
b. Lanes violation
c. Distraction and not taking enough precautions
2. The main causes of injuries in all streets in the study area are:
a. Lanes violation
b. Wrong u-turning
c. Sudden turning
3. The main causes of fatalities in all streets in the study area are:
a. Wrong u-turning
b. Sudden turning
4. The main causes of traffic accidents in all Signalized Intersections in the study area are:
a. Distraction and not taking enough precautions
b. Close following (not enough safe gap)
5. The main causes of traffic accidents in all Un-Signalized Intersections in the study area are:
a. Yield violation (Not respecting priorities of vehicles)
b. Close following (not enough safe gap)
6. Close following between vehicles, driver distraction, lane violations, and yield violation are the leading causes for traffic accidents.

7. From this study, it is concluded that the main causes of traffic accidents, injuries, and fatalities that are related to driver behavior are:

a. Close following and not leaving safe and enough gap between vehicles
b. Lane violations and zigzag driving or passing
c. Being unfocused, and distracted and not taking enough safety precautions
d. Violations of right of way for other vehicles and pedestrians
e. Sudden turning and stopping
f. wrong u-turning and backing
g. Speeding over the speed limit
h. Violations of traffic signs and signals including running on red light

8. The most dangerous and hazardous streets and intersections were located in the study areas. Proper treatments, improvements, and countermeasures are needed to reduce the number and severity of accidents in these areas.

7. Recommendations:

The following recommendations are needed to improve traffic safety in Jordan:

1. It is recommended to improve the driver behavior through the following:

a. Increase enforcement
b. Education and awareness for drivers and pedestrians
c. Increase the role of the Police Friends and the Secret Police
d. Use high technology surveillance of driver behavior such as using stationary and moving radars and cameras.
e. To have a daily news report through the T.V. and Radio stations about the daily traffic accidents, and to show the human losses and the injuries caused by these accidents, also to talk about the social and financial losses that can result.
f. To force drivers who repeat traffic violations to suspend their driving license and to attend training courses concerning traffic laws and regulations.
g. To increase the penalties for speeding, close following, running red light eating, drinking, smoking, using cell phones, zigzag driving, and yield violations.
h. To start educating our children in schools about traffic safety rules and regulations. Also, encourage the students at university level to take traffic safety course.
i. To encourage drivers to drive defensively and to obey traffic rules and regulations in all circumstances.
j. To increase the number of traffic police patrols on the most hazardous and dangerous streets and intersections.

2. Widen the study area to include most areas inside Greater Amman Municipality, and to include more variables in the regression models such as road geometric features and traffic characteristics.
3. Train all the traffic personnel to deal with the statistics programs such as SPSS software and keep them updated with the recent studies and researches regarding traffic safety issues.
4. Update the traffic police personnel with the most common mistakes drivers make, and to give them monthly classes on dealing with traffic safety and congested traffic.
5. To have more collaboration and coordination between all traffic and transportation agencies to improve traffic safety and achieve the goal of reducing traffic accidents frequency and severity.
6. The urgent need to adopt and implement a practical traffic safety strategy that has clear targets, objectives, action plans, time frame, and legislations.
7. The time has come to establish the Jordan National Traffic Safety Council to take its role in handling all the traffic safety issues in Jordan.

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Mohammad Abojaradeh Ph.D., P.E., a Ph.D. graduate of Arizona State University USA in 2003, who got his Master degree from Jordan University in 1997, and his bachelor degree from Kuwait University in 1985. He is specialized in Transportation, Traffic, and Highways. His major research interests are in the performance and improvement of Pavement materials, Traffic studies and Traffic and Pedestrian safety, Highway Engineering Studies, and in Transportation Engineering Studies.