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Identifying Risk Factors Influencing Traffic Accidents for Baghdad Expressways

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HIGHLIGHTS

- Loss of control of the vehicle by the driver for any reason is one of the main causes of accidents on the highways in the capital, Baghdad.
- Traffic accidents are more severe (fatal) when heavy vehicles are involved in the accident.
- Driving at high and violated speed more than 120 km/hr on local highways results in fatal accidents.

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ABSTRACT

In this paper, the SPSS program (version 25) and Binary Logistic Regression Model were used to implement and identify the risk factors that affect traffic accidents on Baghdad highways. Due to the increase in the number of traffic accidents that led to injuries and deaths in Iraq during the past years and the lack of specialized studies in traffic accidents, especially on highways, this required the preparation of a study to know the causes of accidents and to explore the factors that have a relative impact on (the severity of the accident). Four highways in the capital, Baghdad, were chosen in this study, major and vital in terms of the number of drivers who use them daily, which are (Mohamed Al-Qasim Expressway, Army Canal Expressway, Salah Al-Din Street (Expressway), and Baghdad International Airport Street (Expressway)). Three hundred and forty-nine traffic accident forms were collected from the traffic directorates on both sides of Al-Karkh and Al-Rusafa for the years from 2006 to 2019. After the analysis by Binary Logistic Regression, the results showed that (contributing factors, road condition, cause of an accident like (parking on highway, loss of control, lack of attention, sudden stopping and lack of attention), vehicle body type, speed). Resulting from the BLR model.

1. Introduction

Iraq is one of the main moderate-income Arabic countries in which the main mobility approach is vehicle road transport. The growth in road incidents and traffic injury has recently been significant, which should be an intuitive consequence of the high motorization predicted after 2003 due to the economic and population increase [1]. Estimation of some capabilities of intersections in Al-Kut city, including (Al-Kafaat) intersection, to absorb traffic momentum (traffic volumes) and address problems that cause congestion. Data was collected by a digital camera for various directions at the intersection, the level of service at this intersection is equal to (F), a delay of 105.1 (sec./vehicle), so it is necessary to increase the number of lanes on the right side of Al-Haidariya Street to reduce the level of service to (D) with a cycle time of 91 (sec/vehicle) and a delay of 38.1 (sec./vehicle) [2]. Furthermore, this increase may be an important aspect of collisions, especially if succession planning programs are not introduced [3]. Traffic accidents represent important problems that adversely affect social safety and security, the major cause of vehicle accidents is the route, which causes accidents by road design. Besides this, humans have a significant impact on the frequency of accidents, and this is mostly due to neglect or violations of traffic rules by drivers. Traffic accidents reduce road capacity and increase queues, the period of delays depends on the type/period during which an accident occurred, the number of roads affected, the time of response to the accident and the congestion removal, as well as the period required to restore service of the roadway. In addition, Iraqi society's lives have been affected by extremely serious road accidents in Iraq, similar to the existing terrorist activity, which has become one of the major problems reducing our human resources and causing socioeconomic problems and human resources losses. Hence, traffic incidents were known for several

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years as an element to consider the differences between traffic accidents and specific transport networks. Furthermore, there are insufficient road safety specialists, and actual experiences are limited to a few Iraqi experts. The division of these experts and the lack of management personnel for road safety are also lacking [4]. Firstly, Baghdad's reporting system is weak, and no archiving system is available. Second, three factors influencing crash accident severity were indicated: location, type of vehicle, and cause of the accident. Third, segment crash incidents are worse than intersection-based accidents. Finally, where a collision involves heavy trucks and other vehicles, there is a larger risk of a fatal crash [5]. Measured the change in sensations of sleepiness of the participants with a driving simulator for 22 participants in fatigue driving and found that sleepiness is high in hard-driving activities. Various studies in Iraq addressed traffic difficulties and transport concerns, such as [6-8]. The logistic regression model has analyzed risk factors in road crashes. The main risk factors for injuries caused by road crashes, travel causes, the intake of drugs, Mexico-Cuernavaca highway, on weekdays, during daylight hours, and under adverse weather have been identified in this study. Consequently, the severity of accidents should be determined based on the accident scene's current circumstances. The sole derogation from this provision is especially regarding fatal accidents. If any injury causes a fatality, the injury's special status should be changed to a fatal one within a certain minimum amount of time after a road car crashes. The definition of a fatality in road travel varies between countries. In the United States, the definition used in the Fatality Analysis Reporting System (FARS) [9]. It is used by the National Highway Traffic Safety Administration (NHTSA) [10]. The fatality of road traffic is a person who dies within 30 days of a public road fatal collision involving a car with an engine (NHTSA), Fatality Analysis Reporting System, (2010) [11]. A study of traffic accidents in Iraq from 2005 to 2017 showed the classification of traffic injuries according to the number of deaths and injuries during the accident. The highest rates of traffic accidents were recorded in the period from 2014 to 2017. This increase was a result of not taking security precautions in addition to safety precautions, as the results of that study from 2014 to 2017 for these years where the number of injuries increased by 12% over previous years and the number of deaths due to accidents increased in 2017 by 21% of previous years. The aim of this research is to explore factors impacting the severity of crashes on expressways in Baghdad City as the severity of an accidents investigation hasn't been carried out since 2003 for many years. In this research, the effects of statistically significant variables on the severity of the accidents are assessed using binary logistic regression. Many of the regressions have been used to evaluate the risk factor of different diseases via categorical data techniques. BLR is also one of those regressions used in the risk assessments of transportation (road) [12].

2. Method of Analysis

2.1 Data Aggregate and Area of Study

An accident report is the entire criteria for all accident data. There are two categories of reports [13]:

* Report of injury by technicians in a traffic accident filed by each vehicle involved; requirements by the state's law for any casualties and deaths in collisions above a limit for total property damage.
* Police collision records from a police officer in attendance on any injuries involving a person. These include all fatal injuries, most of them serious injury incidents that require hospital or medical treatment and major injury PDO accidents.

Iraq is one of the largest Arab nations, with 438,000 sq km of total access area and an overall population of approximately 40,150,200 million in 2020; nearly 70 % live in urban areas. Furthermore, since 2003 in Baghdad, accident analysis, especially accident severity analysis, has not been performed for several years. Therefore, it has become imperative in this analysis to create baseline knowledge on road traffic accidents (RTAs) in Baghdad, essentially on the expressway. In this study, the focus will be on the incidents in the Iraqi capital, Baghdad. First, we explain their details, the latitude of Baghdad City is 33° 18' 46.0980" N and the longitude 44° 21' 41.3568" E. Elevation of Baghdad City is 39 meters above sea level. [14], population census for the latest official statistics 8,340,711 million distributed over 7,297,432 in an urban area and 1,043,279 in a rural area, as it has the largest population compared to other governorates, the capital, Baghdad, is divided into two parts, Al-Karkh and Al-Rusafa, which the Tigris River crosses. Second, four highways were chosen to study the severity of the collision in Baghdad, two on the side of Al-Karkh (Salah Al-Din street and Baghdad International Airport street) and the Al- Rusafa side (Mohamed Al-Qasim expressway and Army Canal expressway). It must be noted that in Baghdad, there is a General Traffic Department responsible for managing traffic directorates in all governorates of Iraq. Moreover, in Baghdad, there are sixteen traffic stations distributed on both Al-Karkh and Al-Rusafa sides for each special administrative border station. Nine stations on the Al-Rusafa side have one traffic directorate. In addition, there are seven traffic stations on the Karkh side and one traffic directorate. In addition, the field data was collected for the identified (Mohamed Al-Qasim Expressway, Army Canal Expressway, Salah Al-Din Street (Expressway), and Baghdad International Airport Street (Expressway). Figure 1 shows the satellite image shows the location of these Expressways. In this research, the required data collection period is for specific years. In Iraq, traffic accidents are analyzed and studied based on data, which are of two types. Either by preparing a questionnaire and distributing it to a certain number of people who are often participants in a specific traffic accident and ask them several questions and then collect that data and analyze, or depend on government sources, which are more comprehensive as it was collected from hospital records, police stations, or traffic sectors. Furthermore, accidents data available at Central Statistical Organization Iraq (CSO) are in traditional view (not in specific information). They cannot be examined in detail, particularly when the intensity of accidents is evaluated. Hence, the Iraqi ministry is concerned with recording and classifying accidents, which is the Ministry of the Interior - the General Directorate of Criminal Statistics. The only data source for crashes is in Iraq forms filled out by traffic police officers. The main source of road accident data in Iraq (particularly Baghdad) is the traffic police sector. Therefore, in this study, the data gathered from traffic officers have been limited to crash accidents 349 forms, which contain information as shown in Table I. Possible copies of accident reports have been collected manually from traffic officer's sectors in a random process during the period of study from 2006 and 2019. The objective is to identify factors that could affect the severity of the incident (injury plus PDO accident or fatal accident), eight independent variables were summarized from collected collision accident forms. Table 1 below shows the levels and the description for the dependent and independent variables.

Table 1: Explains and describes the data and percentages of dependent and independent variables for each expressway involved in this study

Variable class	Variables	Percent of Accidents (for each expressway)
	Dependent variable	
Accident severity	Injury + PDO	84.0%
	Fatal	16.0%
	Independent variable	
Contributing Factors	Driver	18.4%
	Vehicle	7.2%
	Vehicle and Driver	1.7%
	Unspecified [a]	9.7%
Road Condition	Dry	91.1%
	Wet [a]	8.9%
Weather	Sunny	90.3%
	Rainy	8.6%
	Fog	0.6%
	Cloudy [a]	0.6%
Seat belt	Yes	4.9%
	No [a]	95.1%
Speed(estimate) during the accident (km/hr)	90	0.9%
	100	4.9%
	110	3.2%
	120	22.1%
	130	15.8%
	140	14.9%
	150	7.4%
	160	22.3%
	170	0.9%
	180	5.7%
	190	1.1%
	200	0.9%
Day	Weekday	76.2%
	Weekend [a]	23.8%
Causes	Unspecified	10.3%
	Parking on highway	0.3%
	Wrong turn	5.2%
	Loss of control	31.8%
	Alcohol	2.3%
	Lack of attention	20.9%
	Closing (safety distance)	6.6%
	Sudden stopping and lack of attention	4.3%
	Wrong overtaking	5.2%
	Lane changing (path of driving)	2.3%
	Tire condition (tire explosion)	1.4%
	Tire condition (tire explosion) and Loss of Control	4.9%
	Brake	2.6%
	Moving against traffic (wrong side)	0.9%
	Vehicle defect [a]	
Vehicle Body type	Truck involved	27.8%
	Non-truck involved [a]	72.2%

Description of data

- a: refers to the reference category.
- Fatal: one person or more is killed in a motor vehicle crash suddenly or within 30 days.
- Injury: one person or more were injured when the accident occurred.
- PDO: Property Damage Only.
- Seat belt: Safety belt wear by drivers, while collecting accident data from highways in Baghdad, interviews conducted with traffic officers, the statistics they had about wearing seat belts by the driver and passengers were the highest recorded rate of (5%), referring to the WHO report on the enforcement of the seat belt law in Iraq, where a scale was used to determine the degree of enforcement based on the opinion of the respondents, the scale ranges from 0 to 10 where 0 is ineffective, and 10 is very effective, in Iraq the enforcement was 8 [15].
- Speed during the accident: An official letter issued by the General Traffic Directorate in 2008, in which the speed limit was determined on all roads in Iraq, the speeds were for Muhammad Al-Qasim highways, Army Canal expressway, Salah Al-Din street (Expressway) (100 km/h) and Baghdad International Airport street (Expressway) (140 km/ h), according to World Health Organization Report speed limit for an urban road in Iraq is 100 km/h [15].

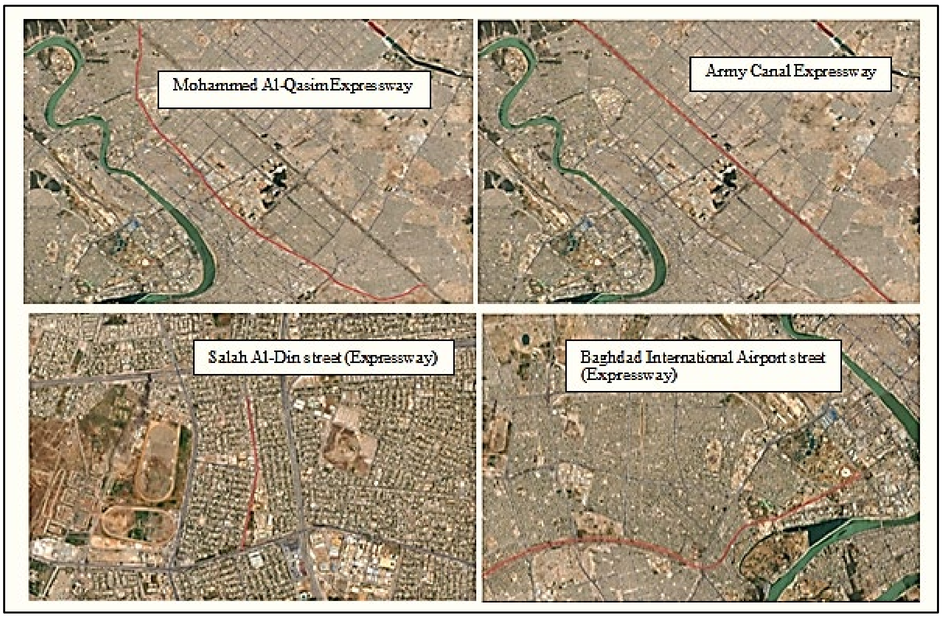

Figure 1: The satellite image of the Location of Expressways (source: Google Maps [16-19])

2.2 Data Analysis by Binary Logistic Regression Model

Logistic regression provides a method for modeling a binary response variable, which takes values 1 and 0. Data are analyzed by binary logistic regression to find out (describe) the relationship between the dependent variable and the independent variables. This results in a change in the odds ratio of the occurrence of significance detected by each variable. By evaluating the relationship of all variables, the advantage of logistic regression is to eliminate confusing results. This analysis aims to establish the relationship between the response variables and independent variables in binary logistic regression and to classify the relative value of independent variables. The logit model in the sample is a logarithm of odds. Hence, a discrete dichotomous variable comes in two types: the dependent variable 0 for injury plus PDO and 1 for fatal. Therefore, one of the dependent variable types (severity) has to be omitted from the model and used as a reference case for estimating the BLR model. This research used non-fatal injuries (injury, property damage only) as a basic group. Table 1 summarizes the factors examined in the BLR model.

Researchers have employed many statistical techniques to analyze driver injury severity. Among these techniques were multinomial logit, nested logit, ordered logit, probit models, and binary logistic regression [5,20-26]. The BLR can be mathematically expressed as in the following the equation:

$$\text{Logit (P)} = \ln \left(\frac{P}{1-P}\right) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_i X_i \quad (1)$$

Where P is the probability of a fatal accident, α is the model coefficient, β_i is the regression coefficient and X_i is the independent variable.

In the Binary Logistic Regression Model, the approximate change in log odds is the fatal accident of each coefficient in a unit increase. Wherever other explaining factors are consistent in the respective factor. For a factor, the coefficient of odds ratio (OR) is an exponential of the coefficient. Therefore, the (OR) applies to how many severe collisions are preferred to a one-factor value (for example, on the weekday) as opposed to the reference case value (for instance, weekend). Hence, if (OR) is greater than 1, the inspecting factor is more likely to be in a fatal collision than the reference variable value. Only certain variables for coefficient values of 0.05 alpha were found to be effective predictors for this model. The BLR model's independent parameters (factors) are only deemed confident when they are important in their significance at a level of 0.05 alpha. Some tests were conducted for data, especially for independent variables, when analyzed by the method of BLR to find out the effectiveness and participation of the entered data in the general model census.

SPSS (version 25) software, Gretl software, and Microsoft Excel worksheet were used to analyze the collected data. During the analysis, this data must pass several tests to ensure that the data fit the model and its correct implementation, like (The likelihood Ratio test, Goodness of fit test).

2.2.1 Likelihood ratio test

The effect of any independent variable on the outcome can be tested using the likelihood ratio (LR) test. If the independent variable contains M types, so each independent variable X_i will have an $M - 1$ non-redundant coefficient (β_i). (X_i) does not influence the dependent variable, the zero hypotheses. The LR test should be used to test the theory. First, the whole model includes all independent variables with the LR statistics LRF resulting in the LR estimates. Secondly, the LR estimates a limited model built with the resulting LR statistical LRR excluding independent X_i variable. Finally, the LR calculates the variance of the chi-square LRF and LRR. The LR statistics are calculated in log-likelihood LL as in Equation (2):

$$LR = [-2\ LL\ (\text{of full model})] - [-2LL\ (\text{of restricted model})] \quad (2)$$

It can be concluded from the likelihood ratio test that the independent variables (expectation) are effective and participate in predicting the outputs. In the general model statistics, if the values of (P) are less than 0.05 at a confidence level of 95 percent. This means that all the independent variables in the model do not equal zero, and all of them are involved in modeling the crash severity for each highway, as shown in Table 2.

2.2.2 Goodness of fit statistics test

To determine the model's suitability in the binary logistic regression, a test of Goodness of fit must be performed and extracted by the general Hosmer-Lemeshow test and the classification table. The Hosmer-Lemeshow test is used to measure suitability to determine whether the expected events are identical to the observed events. The value of this test in the binary regression model is the Pearson's chi-squared statistic in the table of frequencies for the observed and expected events.

Regarding the HL test, a further method to assess the Goodness of fit of the BLR model. In the classification, the real (observed) variable values are categorized to find the right portion of the anticipated events, and the predicted values (at a user-assigned cut-off point, e.g., P = 0.5) are classified. If the expected P is less than or equivalent to 0.5, the statistical proportion assumes that the occurrence does not exist, but otherwise. The overall proportion reflects the total percentage of cases accurately determined by the full model.

Table 2 shows the effects of both methods. All the tests of the BLR model are successful as the value of (P) in the likelihood ratio test was less than (0.05. Its value in the goodness of fit was greater than (0.5). This indicates that the binary model works well with usable data sets.

Table 2: Results of Tests for Binary Logistic Regression Model

The LR statistic Results	
LR statistic	P-value
190.566	0.000
The Generalized Hosmer-Lemeshow Results	
Chi-Square value	P-value
2.818	0.945
The classification Table Results	
Overall % correct	95.4%

2.2.3 Multicollinearity

Cross-tabulation analysis (chi-square test) reveals a multicollinearity relationship between all the independent variables. Binary Logistic Regression requires that the multi-collinearity relationship be the minimum between the independent variables. Therefore, this test matches the independent variables between them (p-value less than 0.05) [5]. For example, the multicollinearity between the road condition vertically and horizontally were the extracts values for phi and significant. If the result of this test indicates the existence of a specific correlation between the independent variables (categorical), other tests such as phi and Cramer's V are used to evaluate the strength of these correlations between the variables ranging from 0 to 1. Hence, the purpose for using multicollinearity, the form used for collecting data: For instance, sampling of a small set of reactionary values in the population, another purpose, particularly in time-series data, for multicollinearity is that the regression in the model shares a common pattern, that is, over time all of them increase or decrease [27]. Results of the Chi-Square Test for Association (Phi & Gramer's V) values for all highways in this study are reported in Table 3.

Table 3: Statistic Results of Chi-Square Test for Association (Phi & Gramer's V)

Independent variables	**Contributing factors**		**Road condition**		**Weather**		**Seat belt**		**Speed (estimate) during the Accident (km/hr)**		**Day**		**Causes**		**Vehicle body type**	
	Phi	*Sig.*	*Phi*	*Sig.*	*Phi*	*Sig.*	*Phi*	*Sig.*	*Phi*	*Sig.*	*Phi*	*Sig.*	*Phi*	*Sig.*	*Phi*	*Sig.*
Contributing factors	------	-------	0.19	0.006	0.22	0.05	0.08	0.53	0.43	0.001	0.08	0.51	0.33	0.00	0.39	0.00
Road condition	0.19	0.006	------	------	0.90	0.00	0.07	0.19	0.21	0.15	0.06	0.29	0.28	0.02	0.09	0.07
Weather	0.22	0.05	0.90	0.00	-----	------	0.17	0.02	0.30	0.60	0.08	0.51	0.36	0.35	0.12	0.15
Seat belt	0.08	0.53	0.07	0.19	0.17	0.02	------	-----	0.11	0.97	0.03	0.58	0.18	0.66	0.05	0.34
Speed (estimate) during the Accident (km/hr)	0.43	0.001	0.21	0.15	0.30	0.60	0.11	0.97	------	-----	0.15	0.77	0.44	0.00	0.31	0.00
Day	0.08	0.51	0.06	0.29	0.08	0.51	0.03	0.58	0.15	0.77	-----	-----	0.21	0.37	0.06	0.25
Causes	0.33	0.00	0.28	0.02	0.36	0.35	0.18	0.66	0.44	0.00	0.21	0.37	------	-----	0.46	0.00
Vehicle body type	0.39	0.00	0.09	0.07	0.12	0.15	0.05	0.34	0.31	0.00	0.06	0.25	0.46	0.00	-----	------

3. Results and Discussion

Table 3 shows the results of estimates for the BLR model. It shows the factors that have a relative effect on participation in fatal accidents compared to collisions in which there are injuries. The outcome of eight variables was introduced in the model for both highways. It was found that five variables (contributing factor, road condition, seat belt, cause of an accident like (parking on highway, loss of control, lack of attention, sudden stopping, and lack of attention), vehicle body type, speed) had a statistical function ($p < 0.05$).

Table 4: Parameter Estimates and Odds Ratios of Binary Logistic Regression Model

Variable class	Variables	Fatal relative to base level		
		Coff.	*Sig.*	*OR*
	Constant	5.181	0.624	17.782
Contributing Factors	Driver	-20.058	0.004	3.513
	Vehicle	-22.483	0.005	2.313
	Vehicle and Driver	-35.673	0.014	2.901
	Unspecified		Reference	category
Road Condition	Dry	-23.989	0.009	40.841
	Wet		Reference	category
Causes	Parking on highway	39.597	0.005	1.573
	Loss of control	14.014	0.032	12.199
	Lack of attention	15.288	0.023	43.597
	Sudden stopping and lack of attention	18.092	0.014	71.989
	Vehicle defect		Reference	category
Vehicle Body Type	Truck involved	2.826	0.005	16.876
	Non- Truck involved		Reference	category
Speed (estimate) during the Accident range from 100 to 160 (km/hr)		0.139	0.004	1.149

The results are interpreted according to the odds ratio in Table4. Shows the value of the odds ratio for the contributing factors (driver, vehicle, vehicle, and driver) is 3.513, 2.313, 2. 901, respectively. This ratio indicates that the probability of a (fatal) collision occurring at (driver, vehicle, and driver) is 3.513, 2.313, 2.901, more than the probability of occurrence in the case of an unspecified case.

The results are interpreted according to the odds ratio in Table 4. For example, the odds ratio value for the road conditions factor is 40.841. This ratio indicates that the probability of a (fatal) collision occurring when the road in the dry case is 40.841 more than the probability of it occurring in the case of the wet road.

The results are interpreted according to the odds ratio in Table 4, which shows the odds ratio value for the cause factor-like (parking on the highway, loss of control, lack of attention, sudden stopping, and lack of attention) 1.573,12.199,43.597,71.989, respectively. This ratio indicates the probability of a (fatal) collision occurring when (parking on a highway, loss of control, lack of attention, sudden stopping, and lack of attention) is 1.573,12. 199 , 43.597, 71.989 more than the probability of it occurring in the case of a vehicle defect.

Heavy vehicles have a higher chance of fatal accidents on highways than other vehicle accidents such as (passenger cars, buses, etc.). Table 4 shows the odds ratio for all highways as the odds ratio for the vehicle body type was found to be 16.876, meaning the probability of a fatal accident in the presence of a heavy vehicle is 16.876 more than the probability and does not happen if heavy vehicles do not participate in the accident. Hence, it obstructed the flow of traffic. This is consistent with the results of the previous study [28].

Also, in this study, most of the accidents were due to exceeding the speed limit, as most of the drivers of these roads do not adhere to the speed limits despite the monotony of the highway from being unqualified and suffering from a severe lack of maintenance and in different sections that do not have fences, as well as a lack of traffic guiding signs in the path of the road. Tables 4. Show the odds ratio for all highways, as the odds ratio for the speed was found at 1.149, which means that the probability of a fatal accident occurring when the speed limit is exceeded is higher than the accident at the specified speed. This is consistent with the results of the previous study [29].

4. Conclusions

The study's key conclusions may well be stated as follows:

1) Traffic directorates data need more detail for highway accidents in Baghdad. Although the reports have more details than the Central Statistical Organization's reports, some were not recorded (causes of the accident, speed, seat belt, time and date of the accident, type of vehicle, type of accident).
2) The data of the Central Statistical Organization needs more details on accidents on highways in the capital, Baghdad. For the past three years, the reports began to have details such as (the number of accidents by road category and the nature of the accident by type of road). However, these reports lack details such as (the age of the driver Education, accident

causes, driving speed, weather condition, road condition, seat belt, number of vehicles involved in the accident, type of vehicle, number of wounded, number of dead).

3) Most accidents were caused by the excess speed limit. In contrast, most road drivers do not obey the speed limits despite the unqualified monotony of the highway and the serious inadequate maintenance in various portions without barriers. Therefore, it is desired that the results of this study would be used by the relevant road safety officer.
4) It is necessary to work on implementing the traffic laws in the Republic of Iraq regarding the driving license for the ages allowed to drive to keep unlicensed drivers off the road. In addition, it is also necessary to prepare a specialized training program with useful courses before granting the license to familiarize drivers with traffic signs, types of roads and the speed to be adhered to when driving on all roads.

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Author contribution

All authors contributed equally to this work.

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Conflicts of interest

The authors declare that there is no conflict of interest.

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