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RESEARCH ARTICLE

Statistical Overview of Factors Influencing Traffic Accidents Severity On El-Brega Coastal Freeway in Libya

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Abstract:

Background:

Globally, Road Traffic Accidents (RTAs) are one of the significant causes of fatality and injury. In Libya, RTAs have resulted in disabilities and were the third leading cause of death. However, there is a lack of information on RTAs and road safety in Libya.

Objective:

The present study aims to fill the knowledge gap by performing a statistical analysis to identify the factors associated with road accident severity in El-Brega Coastal Freeway.

Methods:

RTAs data extracted from police investigation reports in Ajdabiya Municipality for the period from 2001 to 2010. Then descriptive analysis and Binary logistic regression model (BLM) are applied to analyzing the data.

Results:

Descriptive analysis results showed that between 2001 and 2010, approximately 45% of RTAs in Ajdabiya Municipality occurred on El-Brega Coastal Freeway, and more than 1225 individuals lost their lives or sustained injuries in these RTAs. Furthermore, Sixty-two percent (n = 137) of those who died in accidents were from the 20-45 age group. BLM Results concluded that only eight predictors have statistical significant with accident injury severity. Five of them increase the likelihood of injury severity. A head-on collision is the prime influence factor to increase injury severity odds, followed by high-speed driving, Weekends, horizontal curves, and driver's age. While accident injury tends to be less severe with the other predictors like rollover collision, rear-end collision, and accidents involving animals.

Conclusion:

Thus, implementing the use of seat-belt and speed control regulations, with activating ambulance services are the urgent countermeasures to enhance road safety.

Keywords: Coastal freeway, Descriptive analysis, El-Brega Road, Libya, Traffic accident severity, BLM.

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1. INTRODUCTION

For a long time, road traffic accidents (RTAs) have been a serious problem for the general public and government agencies. Societies, in general, have to endure pain and suffering as a result of severe accidents, and this problem is even made worse by the expensive cost of medical care and rehabilitation. Libya has the highest rate for road traffic deaths in the world; in 2015, the death rate was estimated to be 73.4 per 100,000 individuals [1]. Road traffic accidents cause approximately 4-5 deaths each day and are the third leading cause of death in Libya; they have also resulted in a high number of disabilities. These problems have become a social and economic burden on the country [2]. For that, a statistical analysis of

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traffic accident data on El-Brega Coastal Freeway, Libya, between 2001 and 2010 was conducted in this study. Libya has a large land area, and the transport system is very dependent on long road networks. The main road network in Libya is the coastal road (1800 km), and almost half of the fatalities occurred on this road [3]. The road section within the Crescent Petroleum (El-Brega Coastal Freeway) is approximately 230 km long, and it plays an important role in the economic development of the area. It connects the four main oil ports in the country: Azzuwaytinah, Marsa-el-Brega, Ras Lanuf, and EI-Sidra. The present study investigated the RTAs on the road section that extends from the city of Ajdabiya in the east to the port of Ras Lanuf in the west, which is 200 km long and known as El-Brega Coastal Freeway.

Even though RTAs are a very serious problem in Libya, very few studies on road accidents have been conducted in the past. Mekky [4] conducted a descriptive study of RTAs in Libya and reported that road accidents caused 10% of all deaths. One-third of the fatal crashes and almost half of the casualty occurred on the major coastal road, which does not have an ambulance service. The study also pointed out the dearth of data on road geometry, traffic volume, and detailed information of traffic accidents. Hamza [5] investigated the causes of RTAs and injury pattern and found that most injuries were sustained by individuals aged 15-30 years, only 8.2% of the drivers and 7% of the front seat passengers fastened their seatbelts, and 53% of the drivers who did not fastened their seatbelts sustained head and neck injuries. Only 7% of those involved in accidents were transported by ambulance. Bodalal *et al*. [6] conducted a descriptive study for a 10-year period by using data from a hospital in Benghazi. They found that almost 41% of the injuries caused by traffic accidents required surgeries due to accident injury severity. The victims of the accidents were categorized as follows: 28% drivers, 37.7% passengers, and 30% pedestrian; 29% of the patients were between 20 and 29 years, and 22% of the patients died in the hospital. Bodalal *et al*. [7] studied RTIS patients with neurological trauma who were treated at the Al-Jalaa Hospital in Benghazi and found that RTAs were the second main reason for traumatic spinal cord injury.

However, the available reviews were only a descriptive analysis of limited and undetailed data; hence, the present study aimed to perform a statistical analysis of traffic accidents in Libya using detailed and reliable data. Since about one-third of fatal crashes and almost half of the casualties happened on the major coastal road [4], therefore this study investigated the factors associated with accident severity in a 2L coastal freeway (El-Brega freeway section) during the past decade.

2. STUDY AREA

El-Brega Coastal Freeway considered a study area regarding its economic and geographical importance. El-Brega Coastal Freeway stretches 200 km from Ajdabiya (30°44′54.88″N and 20°13′10.11″E) to Ras Lanuf (30°29′34.05″N and 18°33′35.08″E) (Fig. **1**). It is the main network of the coastal road of Libya; it also serves the main oil ports. Furthermore, stretches along with populated areas, such as the old town of Brega, Bisher town, and Al Aqeelah village. The road passes through a semi-desert area with sporadic Sabkha and dunes, where the northerly wind creates sandstorms that often obstruct horizontal vision and dump the sand on the way.

El-Brega Coastal Freeway is a part of the Libyan coastal road; it is a paved road extending from the Libyan-Tunisian border in the west to the Libyan-Egyptian border in the east. The road was constructed in 1937 when Libya was colonized by Italy and was initially named Italo Balbo. It was then reconstructed in the 1970s. The road wide is a 7.5 m two-lane rural road with unpaved shoulders (1.00 m) and vertical drop-off asphalt edge. This could pose a danger to drivers who drift off the road because they might not be able to re-enter the road safely and thus are susceptible to rollover collision. The nature of the terrain in the region and the presence of Sabkha indicate that the road was constructed on rolling terrain with many vertical and horizontal curves; this resulted in a short sight distance, which could make overtaking dangerous and cause traffic accidents. Lack of periodic maintenance, climate condition, high traffic density, and heavy loads have all resulted in the aging of the road and poor pavement condition, where defects such as depression and cracks are observed on the road (alligator cracking, longitudinal cracking, raveling, slippage cracks, and potholes). El-Brega Road does not have adequate traffic signs and road surface markings to help control traffic and ensure safety. No warning signs (*e.g.*, speed limit, no overtaking, slope, dangerous bends, T-junction, animal crossing, and drifting sand) are present along the road. All these factors combined result in poor safety conditions.

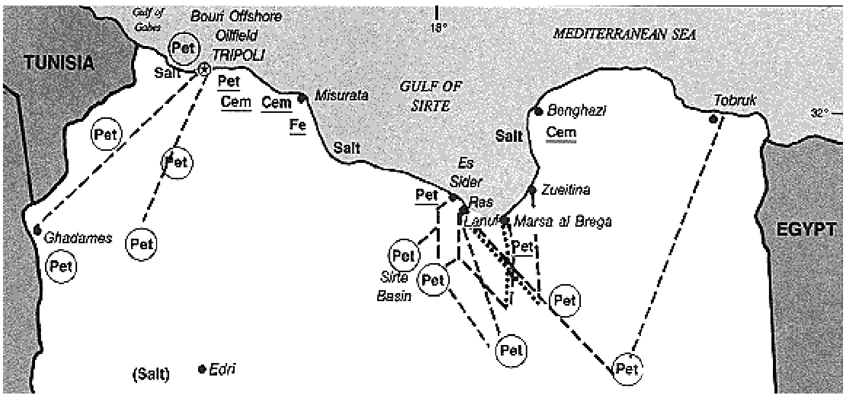

Fig. 1. Main oil ports in Libya (source: http://globalresourcesnews.com/p-libyaoilmaps)

3. METHODS

3.1. Data Collection

In the present study, the author has extracted the data from 1255 cases of accidents investigation hardcopy reports at Ajdabiya traffic police center. Due to the lack of computerization in the traffic police center, the data were archived as a hard copy format, and the accident investigation reports were handwritten, without uniform form, and no data coding. For that, the data collection was conducted manually, and then Microsoft Excel was used to construct and to code an electronic database from 2001 to 2010. The database was constructed based on temporal and spatial factors of the accident and contained detailed information about the vehicle, driver, passenger, type of accident, cause of the accident, and accident injury severity. For modeling purposes, accident severity was classified into two levels of the KABCO scale: minor injury and severe or fatal injury [8]. Other variables, including the age of the victim, spatial distribution, temporal distribution, type of accident, cause of the accident, and vehicle type, were taken into consideration in this study. Only 565 of RTAs occurred on El-Brega Coastal Freeway were considered in this study.

3.2. Descriptive Analysis

Descriptive analysis of the data was conducted using the two-way frequency table to examine the association between the independent variables and accident severity. Data were analyzed using STATA 15 software. However, high frequency does not mean they are statistically significant. For example, vehicle Type “passenger car” has a high rate of accidents occurring but has no statistical significance in the final model.

3.3. Logistic Regression Analysis

The logistic regression model is a statistical method that is frequently used by road safety researchers to analyze data when investigating the association between various factors and crash severity. In this study, injury severity in crashes was defined as a binary variable. A binary logistic regression model was developed to predict accident injury severity in El-Brega Coastal Freeway by using the binary model in the analysis.

BLM can be formed as follows:

$$log\left[\frac{P_i}{1-P_i}\right] = \alpha + \beta_1 x_{i1} + \beta_1 x_{i1} + \cdots + \beta_K x_{iK}$$

Pi=Prob. yi= yi/Xi is the response probability to be modeled and yi is the first ordered level of y

$$\alpha = Interceptparameter \beta = Vectorparameters$$

$$X_i = Vectorofexplanatoryvariables$$

The odd ratio for dichotomous explanatory variable x, which takes a value of 1 or 0 (1 indicates that the event will absolutely occur and 0 indicates that the event will absolutely not occur), can be expressed as the ratio of the predicted number of times when an event will occur (x = 1) to the predicted number of times it will not occur (x = 0). The flowing formula can illustrate this condition:

$$= \frac{\pi(1)/[1-\pi(1)]}{\pi(0)/[1-\pi(0)]}$$

Where

= Odd ratio

$\pi 1/1\text{-}\pi 1$ = Odds that the event will occur when x = 1

$\pi 0/1\text{-}\pi 0$ = Odds that the event will not occur x = 0

4. DATA ANALYSIS AND RESULTS

4.1. Descriptive Analysis

4.1.1. Traffic Accident Distributions in State Roads of Ajdabiya Municipality

Of the five state roads in Ajdabiya Municipality, El-Brega Road has recorded the highest percentage of road accidents. Fig. (**2**) shows that approximately 45% (n = 565) of road accidents occurred there, and 20% (n = 248) of the 1225 individuals involved in the accidents died, 32% (n = 387) were severely injured, and 48% (n = 590) suffered minor injuries. Table **1** shows the trend of accident injury severity as a result of accidents on El-Brega Road during the last decade.

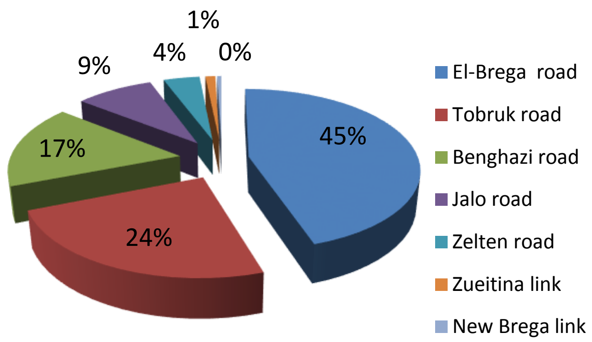

Fig. 2. Traffic accidents distributions of state roads in Ajdabiya Municipality, Libya.

Table 1. Accidents frequency & severity on El-Brega freeway.

Year	Accidents	Fatalities	Severe Injury	Minor Injuries
2001	33	16	22	29
2002	32	16	19	26
2003	35	5	17	33
2004	38	17	24	31
2005	22	16	19	21
2006	77	38	69	55
2007	81	23	33	95
2008	79	20	70	123
2009	82	56	66	86
2010	86	41	48	91
Total	565	248	387	590

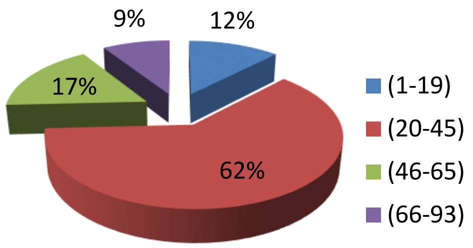

Fig. 3. Age distribution of individuals who died.

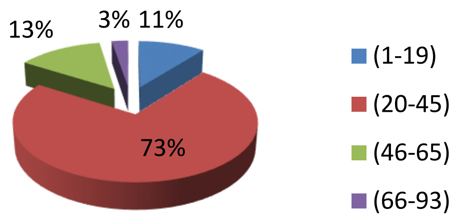

Fig. 4. Age distribution of severely injured individuals.

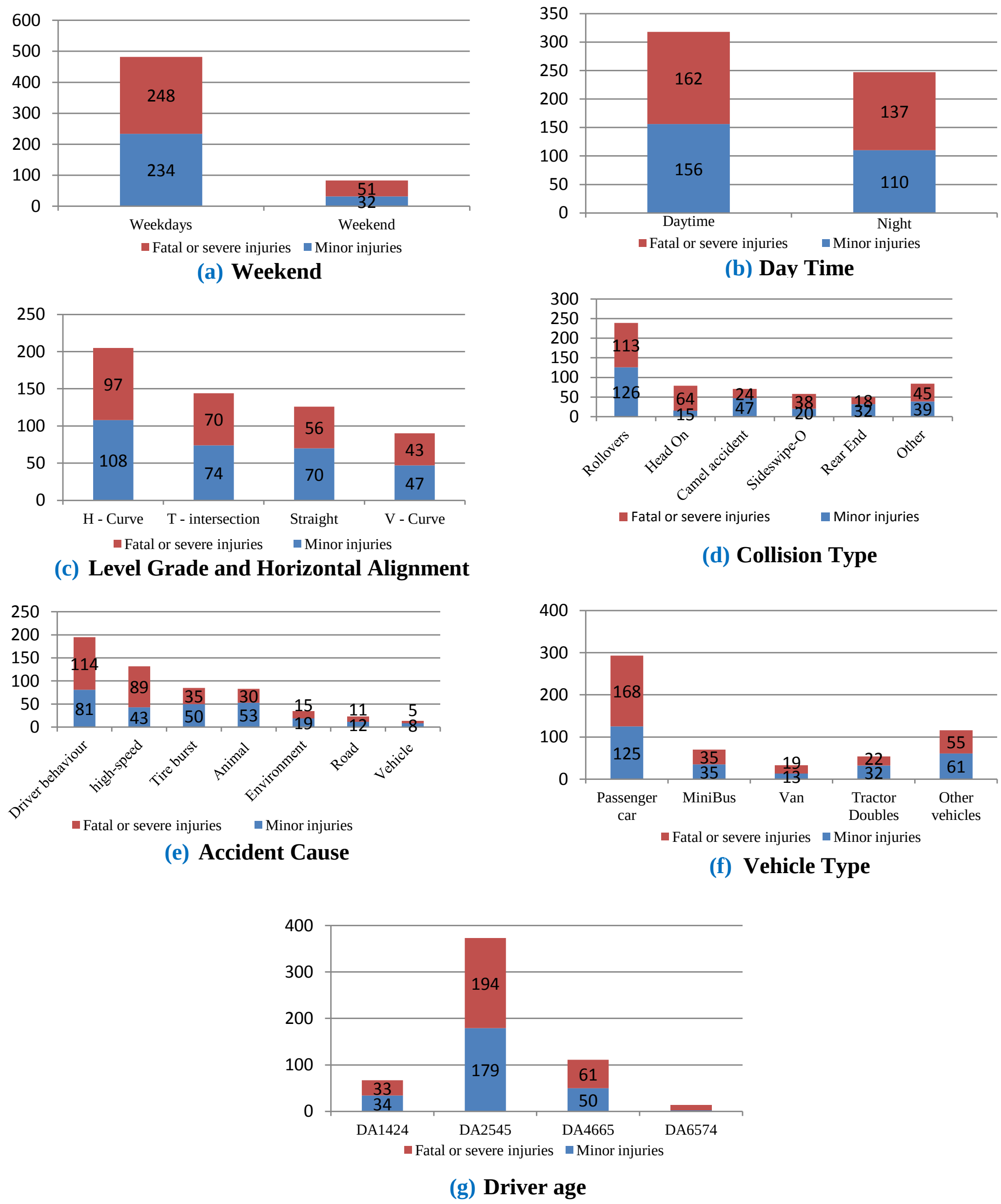

Fig. 5. Accidents severity with study variables.

4.1.2. Age Distribution

The age of individuals who were injured ranged from 1 year old to 93 years old. Sixty-two percent (n = 137) of those who died in accidents were from the 20-45 age group, whereas 73% (n = 256) of those in the 20-45 age group sustained severe injuries (Figs. **3** and **4**). This is a serious concern because the majority of those who died or were severely injured are from the working-age.

4.1.3. Accidents Severity with Study Variables

Only a data set of 565 RTAs occurred on El-Brega Coastal Freeway were considered in this study. Retrospective descriptive statistical analysis (two-way frequency table) were used to investigate the association of accidents severity with temporal characteristics, road geometric, collision type, accident cause, and vehicle type on El-Brega rural freeway. We can see that there is a variation in accident severity levels in Fig. (**5**). Some study variables show a varying percentage of severity. However, such a superficial analysis is not sufficient to decide if the variable is correlated with accident severity or not.

4.1.4. Accident Black Spots on El-Brega Freeway

Accident black spots are presented in Table **2**. The table shows that 62.7% of all traffic accidents on ElBrega freeway occurred in specific locations. The frequency and severity of traffic accidents at these locations are likely due to road geometry and lack of traffic control. Nevertheless, human and environmental factors should still be considered.

Table 2. Accident black spots in El-Brega freeway.

Location Km - (Name)	Accident %	Frequency	Severity %	Location Description
18	11.0	62	42	H-curve
66-(New Brega-entrance)	8.0	45	49	T- intersection
124 - (Al Aqeelah)	5.8	33	55	Small town
40	5.7	32	44	H-curve & V-curve
100 - (Bisher)	5.7	32	69	Small town
77- (Old Brega)	4.6	26	62	H-curve
35	4.1	23	57	H-curve & V-curve
20	3.7	21	43	Street
30	3.4	19	58	Vertical curve
69 - (Bright Star University)	3.4	19	42	T- intersection
72 - (Sirte oil co-camps)	3.4	19	79	T- intersection
25	2.3	13	38	Vertical curve
129	1.6	9	44	H-curve
Other locations	37.3	-	-	-
Total	100	-	-	-

4.2. Statistical Modeling

As shown in Table **3**, only Twenty-three variables were first considered for this study. At first, the Univariable analysis has been done to test the associations between the predictors and the outcome, a level of <0.10 is chosen as the level of significance to identify variables known to be important. The variables with an effect on crash injury severity at a level of significantly higher than 90% (*i.e.*, $\alpha \geq 0.90$) were included in the model development process. Second, collinearity was checked to identify the associated collinear pairs for retaining only one of the variables. Third, the stepwise backward elimination method was followed to select a set of predictors, only statistically significant variables at the ***p***= 0.05 level should stay in the model. Finally, Goodness-of-fit (GOF) statistics were used to evaluate Model adequacy, and the Hosmer-Lemeshow test result shows that the model fits well with ***p***-value = 0.2435. Table **4** presents the final model with significant predictors. STATA 15 software was utilized in the analysis.

Table 3. Summary of Predictor variables, variable codes, and *p*-values in the univariable analysis.

Variables	Code	Description of Variables	*p*-value
Temporal Characteristics	-	-	-
Weekend	WE	Weekdays=0 Weekend=1	0.093
Day time	TIM	Day time=0 Night=1	0.286
Road Geometric			
Level grade	LGRA	Not leve=0 Leve=1	0.165
Horizontal alignment	HALL	Straight=0 H-curve=1	0.010
T - intersection	T_INT	No Intersection=0 T - intersection=1	0.670
Collision Type	-	-	-
No of vehicles in accident	VNO	Otherwise=0 One vehicle=1	0.003
Rollover accident	AROV	No Rollover accident =0 Rollover accident =1	0.049
Animal accident	AANI	No animal accident =0 Animal accident =1	0.002
Head on accident	AHON	No Head on accident =0 Head on accident =1	0.000
Rear end accident	AREN	No Rear end accident =0 Rear end accident =1	0.001
Sideswipe-opposite accident	ASSO	No Sideswipe-o accident =0 Sideswipe-o accident =1	0.050
Accident Cause	-	-	-
Human factor	CHUM	No Human cause=0 Human cause=1	0.126
Tire burst factor	CTIR	No Tire burst cause =0 Tire burst cause =1	0.060
Driver speed factor	CDSP	No Driver speed cause =0 Driver speed cause =1	0.000
Animal factor	CANI	No Animal cause =0 Animal cause =1	0.001
Weather cause	CWEA	No Weather cause =0 Weather cause =1	0.378
Road factor	CROA	No Road cause =0 Road cause =1	0.623
Vehicle factor	CVEH	No Vehicle cause =0 Vehicle cause =1	0.118
Driver ge	AGE	Continues variable	0.074
Vehicle Type			
Passenger car	VPAS	No Passenger car =0 Passenger car =1	0.029
Mini Bus	VMIN	No Mini Bus =0 Mini Bus =1	0.601
Tractor doubles	VTRC	No Tractor doubles =0 Tractor doubles =1	0.062
Van	VVAN	No Van =0 Van =1	0.453

5. DISCUSSION

This study applied BLM to analyses 565 cases of accident records, and the odd ratio used in model interpretation. The results of the statistical analysis were as shown in Table **4**. In the final model, only eight of the examined variables have significant impacts on accident injury severity of rural freeway accidents at a significance level of 95%.

Table 4. Final model result for accidents severity in El-Brega freeway.

CEVE	S.E.	Odds	*p*-value	95% Conf. Interval (Odd)	
WE	.4527011	1.723816	0.038	1.030273	2.88423
HALL	.4072209	1.654342	0.041	1.021174	2.680099
AROV	.1211641	.528479	0.005	.3371889	.8282897
AHON	1.112647	3.279424	0.000	1.686557	6.376674
AREN	.0951169	.2660735	0.000	.1320417	.5361572
CDSP	.511852	2.161637	0.001	1.359026	3.438255
CANI	.1308355	.4517312	0.006	.2560622	.7969199
AGE	.0080833	1.018669	0.020	1.002948	1.034635
_cons	.192314	.5690706	0.045	.2934321	1.103633

5.1. Temporal Characteristics

Although the weekly distribution of road accidents in Fig. (**4a**) shows that more accidents occurred on weekdays. However, the model result shows that most crashes happened on the weekend are more severe than those that happened in weekdays with OR = 1.72. This finding is similar to that of Yu & Abdel-Aty and Shrestha & Shrestha [9, 10]. For instance, Shrestha & Shrestha [10] attributed that most drivers traveling on weekends are less familiar with the roads. Regarding daytime and night, descriptive analysis in Fig. (**4b**) shows a slightly difference between accidents frequency and severity. Moreover, day time is not significant in the final model.

5.2. Road Geometry (Horizontal Alignment)

The graph in Fig. (**4c**) shows that the horizontal curvature contributes to increasing accident frequency; also, horizontal curves represent 43% of Accident black spots, as shown in (Table **2**). In final mode, injury severity at the horizontal curve rises by 65% with OR= 1.65, as well as same is the case in the most previous researches that have confirmed that accidents occur more frequently and more severely on a horizontal curvature [11].

5.3. Collision Type

Crash investigation reports listed 15 types of first harmful events. In the present study collisions were sorted into six categories. The first five categories of collisions were a rollover, head-on, accidents involving camels, sideswipe-opposite, and rear-end. The sixth category, which comprised all other types of collisions, had a low percentage of occurrences. Several other studies have used this accident classification Kim *et al*. and Tavris *et al*. [12, 13]. Referring to the Descriptive analysis results Fig. (**4d**), we can see clearly that rollover collision is the most frequent. Nevertheless, the final model result shows that rollover collision is 47% less severe than other accidents types with (OR = 0.53). In the descriptive analysis, head-on collisions accounted for only 14% of total accidents. In spite of this, modeling result (Table **4**) shows that head-on collisions influencing accidents severity in El-Brega freeway by an odds ratio of (OR = 3.28), indicate the probability of severe injuries in head-on collisions which is 228% higher compared to other types of accidents. This finding is consistent with those of Deng *et al*.; Şimşekoğlua *et al*.; and Hosseinpour *et al* [14 - 16]. Deng *et al.* [14] found that fatal head-on crashes are much higher on undivided rural two-lane highways than on other types of roadways.

A rear-end collision is less severe than other accidents types, as shown in the Table **2**. The odds ratio of rear-end accidents is 0.27. Our result in line with the previous finding; for example, Kim *et al.* [12] reported similar findings that rear-end collisions rarely lead to a severe injury. Camel accidents and Sideswipe-O do not have any statistical significance.

5.4. Accident Causes

Police investigations reported the causes of accidents in 42 categories. The percentages for some categories were very low and were therefore combined into four groups, namely, driver behavior, environmental-related causes, road-related causes, and vehicle-related causes. Several essential causes of accidents were listed separately, such as high speed, tire burst, and animals, as illustrated in Fig. (**4e**). Even so High-speed caused only 23% of accidents. However, it has statistical significance in the final model result, as shown in (Table **4**), indicating high speed which leads to severe injuries probability by 116% with OR = 2.16. This result quite agreed with the literature which concluded that speed had been known to have a high likelihood of causing the most severe accidents [17, 18]. For example, Da Silva *et al.* [18] found that high speed increased the risks of occurrence and the severity of accidents. High-speed driving has been known to have a high probability of causing the most severe accidents [17]. Descriptive analysis shows that animals cause a small portion of accidents. And the odds ratio of involved in vehicle accidents is OR= 0.45, which means that accidents caused by animals are less severe compared to other causes. If we know that, the vast majority of animals in this study are camels; the finding is inconsistent with the previous results. For instance, Al Shimemeri and Arabi [19] stated that big animals (*i.e.*, camel) involved in traffic collisions usually result in severe injuries to passengers. In the present study, the vast majority of animals are camels. We argue that this contradiction may be related to the difference in drivers behavior from country to others; in such situations, drivers may have familiarity with camels grazing areas. Although descriptive statistics in Fig. (**4e** and **f**) show that driver behavior made up the highest percentage of accidents caused, and about 60% of these accidents were severe. However, this factor has no statistical significance in term of accident severity. Additionally, environmental-related causes, road-related causes, and vehicle-related causes, and tire burst did not have statistical significance in term of accident severity.

5.5. Driver Age

Fig. (**4g**) shows that driver of the age group 25-40 tends to have the highest accident frequency, however the severity ratio is almost the same as in all age groups (50%). In addition, in the model result, driver's age seems to be a significant factor, nevertheless, had a minor effect on accident severity, as each change in the aged unit (year) is accompanied by 2% (OR= 1.2) increase in the severity of the crash. This finding is somewhat consistent with the most common conclusion in the previous researches, the increasing of driver age increase the severity of the injury [20, 21].

6. RECOMMENDATIONS

Study finding could help transport authority to facilitate the formulation of road safety countermeasures, and the following measures are proposed to improve traffic safety on the El-Brega freeway in Libya:

1- Road geometry and traffic control should be evaluated in accident black spots.
2- Enforcing seat-belt use and speed control regulations have a meaningful impact on saving lives; also ambulance services have to be activated.
3- Finally, such roads with economic and geographical importance require an optimal solution to mitigate traffic accidents and their consequences. For that El-Brega Coastal Freeway should reconstruct to be a double way with several lanes to enhance traffic safety.

CONCLUSION

Retrospective descriptive and binary logistic regression model (BLM) was used to investigate accident injury severity in El-Brega Coastal Freeway by using a detailed dataset of RTAs extracted from Ajdabiya Traffic Police Department archive between 2001 and 2010. Descriptive analysis showed that between 2001 and 2010, approximately 45% (n = 565) of all road accidents occurred on El-Brega Road in Ajdabiya Municipality and that more than 1225 individuals died or were injured as a result of these accidents. Most of the casualties involved individuals in the working-age group (20- 45 years old). BLM technique was used to investigate the factors that contribute to accident injury severity in El-Brega Coastal Freeway, a set of 565 crash records to define the predictors that would fit the most suitable model. To the best of the authors' knowledge, no previous study was conducted in the rural freeway in Libya. Therefore, the present study aims to fill the gap by conducting a statistical analysis. The final model result shows that only eight predictors have a significant influence on accident injury severity at a significance level of 0.95. Some predictors increase the likelihood of accident injury severity; like Weekends, horizontal curves, head-on, high-speed driving, and driver age. However, accident injury severity probability tends to be less severe with other predictors like rollover collision, rear-end collision, and accidents involving animals. Furthermore, some other conclusions extracted from the investigation report are as follows: (1) Lack of the usage of seatbelt; (2) No speed control on roads; and (3) Absence of ambulance services in rural freeways, which leads to increase death probability among severely injured people. Study finding could help transport authority to draw a road safety plan.

There are limitations to this study. There is no traffic data, geometric road data, and nor pavement information available from the official authorities. Thus; these factors weren't considered in the present study.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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