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Analysis of Road Accidents in Baghdad City

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Abstract— Road traffic accidents (RTAs) have turned out to be a huge global public health and development problem causing enormous economic and social costs. Therefore RTA has become a major concern and analyzing accident data has been an important look out to the analysts in order to find the major factors related to the accidents, and to predict the future road accidents in order to mitigate and/or eliminate them in the future.The study revealed that the main contributing factor is the human. The predominant type of crashes was run over with 53% of the total crashes.Approximately, 53% of crashes occurred on major roads, 58% of crashed occurred during day time, drivers with group ages between 24 – 29 years' experience more crashes, and single vehicle accidents result in more casualty (fatality and injuries) compared to multi-vehicleaccidents. The most important resultobtainedfrom this study, a prediction model which link accidents with the number of registered vehicles and population.

Keywords— Accidents analysis, Prediction model, Baghdad city, Roadway safety, Crash data.

1. Introduction

Transportation is the vital sector that the other sector of the economy, so the movement of persons or material from where they are to where they like preferred is served through means of transportation. There are many problems related to transportation, vehicle accident/crash is widely distributed throughout the world. A vehicle accident is road traffic incident that usually involves one road vehicle colliding with another vehicle or other road user, animal, or stationary roadside object and may result properly damage, injury and possibly death [20]. The World report on RTAs prevention has indicated that worldwideclaim more than 1.2 million lives each year, while the number of injured could be as high as fifty million and have a huge impact on health and development,and cost governments approximately 3% of gross domestic product [35]. Traffic crashes cannot be absolutely eradicated [8]. However, it is possible to prevent them to some extent as long as the contributing factors are identified and tackled appropriately. In general factors that contribute to road crashes are[19]; (1) Human: including age, judgment, driver skill, attention, fatigue, experience and sobriety. (2)Vehicle: including design, manufacture, and maintenance (e.g. breaking system). (3)Roadway/Environmentincluding geometric alignment, cross-section, traffic control devices, surface friction,grade, weather, visibility.These contributing factorsinfluence the sequence of events before, during, and after a crash.By understanding these factors and how they might influence the sequence of events, crashes and crash severities can be reduced by implementing specific measures to target specific contributing factors[19]. In Iraq (is one of the developing countries in the Middle East), like other countries, traffic accidents are one of the leading causes of death. The growth in popularity of the automobile ownership is the major developing problem without updating of transportation network (e.g. construction of new roads or using new traffic system), especially inBaghdad City – capital of Iraq. The lack of efficient traffic system and program to serve and arrange the traffic movements and poor design/maintenance for roads are creating many traffic problems and requirements. Traffic accidents represent the general problems related to an increment of traffic volume and demand. Because Iraq is suffering from the effects of road accidents, it is necessary that an effective plan be coordinated to protect the country from excessive social, economic, and health losses, through analysis of traffic accidents, find contributing factors and establishingcountermeasures to correct them.

2. Literature Review

Some of past studies in Iraq are briefly reviewed here.A researcherfound that road width shoulder, median width, lane width, and average spot speed appear to have high effect on accident rates for multilane highways.While for two lane two way highways the most effective variables are shoulder width, spot speed, lane marking, and cross slope[2].

In another studyfound that most of the accidents approximately 66.1 % were not reported and 89 % of the accidents occurred due to violation of traffic sign [3].

It had beenconcluded that due tothe limited and uncompleted traffic accidents data, the traditional safety improvement programs such as hazardous road location (HRL) program cannot be applied in Iraq [12].

A study performed after 2003, the aim of study was tosuggest an electronic reporting application for traffic accident reportsand not analysis of traffic accidents [4].

Some of previous international studies regarding collected dataare briefly reviewed here.The growing number of motor vehicles is considered as one of the main factors contributing to the increase in global road crash injury. Smeed is the first who illustrated a relationship between fatality rates of traffic crashes and motorization level (number of vehicles per 1000 capita) [39].There are various studies that examine the relation between congestion and safety, and their outcomes are quite diverse. However, according to study [11] crash rates decrease at high density levels, and crash severity is greatly reduced when all lanes present similar flow conditions [15].

A study shows that roadways with access management have between 50 and 65 percent fewer accidents than roadways with no access management [6]. The difference is mostly due to the presence of at-grade intersections on arterials, which lead to more stopping and starting that causes potential conflicts between turning vehicles, pedestrians and cyclists.

Recent studies have shown that collision of vehicles with pedestrians and motorcyclists have the highest rates of injury in Asia [40, 43]. This type of accident is considered too dangerous and usually results either in injury, serious injury or fatal injury. Run over accidents (collision of vehicles with pedestrians or motorcyclists) are highly effected by volume of pedestrian/cyclists, volume/speed of traffic, crossing width, vulnerable userson roadway, limited sight distance, inadequate barrier between vulnerable users and vehicle facilities [19].

The performance of the driver of one or both of the vehicles involved is the major contributing cause of many crash situations [32]. A 1985 report based on British and American crash data found; driver error, drinking and other human factors contribute wholly or partly to about 93% of crashes [18]. Theoretically, professional taxi or bus or truck drivers are at a greater risk of being involved in a vehicle crash, due to their occupational exposure to hazardous fatigue and stress [23, 29].

A study performed in England, it has been determined that 69 percent of all traffic accidents occurred in daylight [7].In another study performed in India, 60 percent of the accidents were recorded during day time [16].

Regarding Age of drivers, It is had been stated that the road crash injury is a leading cause of death for young drivers and riders,as both young age and inexperience contribute to the high risk of these drivers and riders[34]. Additionally, in one of studies it has been concluded that young male drivers are involved in more accidents than all other drivers when accident statistics from all over the world are considered [22]. Furthermore, 53% of the people who die in road accident are the most productive age group of 20 to 50 years [35].

There are many factors affecting the severity of single vehicle and multiple vehicle accidents. Martensen and Dupon compared the SV (single vehicle) and MV (multi-vehicle) fatal crashes from six European counties [27]. It was found that the most important variables to differentiate between SV and MV crashes were traffic flow, the presence of junction and presence of physical division between carriageways [27].The MV crashes occurrence was found to be related to the degree of curvature, curve length ratio, lane number and median width. However, the SV crashes were more associated with the median width, speed limits, lane numbers and longitudinal grades [44].With respect to road user characteristics, for young drivers crashes are more likely to be SV crashes than for older ones [9, 24, 33].In order to examine the factors affecting severity of SV and MV, it is recommended to review a study conducted by Hany M. Hassan [17].

3. Objectives of Study

The main objective of this study is to analyze characteristics of crashes andhighlighted issues related to crash data.Findings from the present workcan help transportation agencies to develop effective policies or appropriate strategies of reducing crash frequency and crash severity.

4. Data Sources and Limitations

In many developed countries, data may come from different sources, including police, insurance, and hospital records. The situation, however, is different in developing countries, where the only sort of data is the police and data are not collected with a view to providing research information but for the purposes of litigations [14, 36]. Therefore, such data do not have detailed information to carry out in-depth research.Similar to other developing countries, the main source of road accident data in Iraq is the police, when the crash occurs, the traffic officers have to fill the accident reportand deliver it to the local police (police stationwithin the administrative boundaries).It is worth mentioning that, according to the legal instructions,

there should be four copies ofan accident report, but actually, there are only two copies, one for police station and another for traffic officer and often, there is only one copy for police station. In the same time, the investigating officer from police station has to come to the crash scene in order to create investigation reportwhichis considered as the confidential information for security reasons. The investigation report involve all related information to drivers, passengers, witnesses if available, vehicles, time, date and location of accident, then the accident form has to be added to the investigation report and sent together to the court as litigation (law case). Many of the litigation regarding accidents do not involve accident report because either the vehiclesare removed from crash location before the arrival of traffic officer(s) or,due to some reasons, the traffic officer(s)do not arrive to the accident scene.In addition to that, there is no copy of the accident report to be saved for records. Moreover, many of the property damage only (PDO) accidents do not reported by investigating officer or traffic officer especially when there is no damage to the public property, and when there is a reconciliation and agreement between related parties of accident. Such data reveal four main problems with police records; (1) there is no record for accident reports, (2) most of accident data were restricted to the fatal and injury accidents (i.e., no consideration for (PDO) accidents), (3) reporting system is primitive (i.e., reports are filled manually and no computerization is made to maintain data), and (4) deficiency in reporting system exists due to incomplete, unclear, and/or incorrect data. Besides that, the reliability of police reports is questionable because traffic officer/investigating officer are not trained as engineers and look for prosecution data rather thanengineering problems. Thus, researchers face difficulties in collecting accident data due to manual searching with traffic officers or in the files, if they are available and other mentioned problems. In this study, Traffic Accidents Statisticsdata for period between 2010 and 2016have been adopted from Central Statistical Organization Iraq (CSO), which are yearly published by the Directorate of Transport and Communication, Ministry of Planning. The Directorate of Transport and Communication provides police stations with specific tables regarding traffic accidents. These tables have to be filled and sent on periodic basis to the police directorates, and then (after merging the monthlytables) to the Center for Criminal Statistics at Ministry of Interior. In this location, tables have to be merged for each province.Final tables are, finally, sent to the Directorate of transport andCommunication, Ministry of Planning.

In addition to the traffic accident data, total numbers of registered vehicles and population for the same period have been takenfrom CSO. The next section reviews and analyzes collected accident data. Sufficient data for many purposes are, unfortunately not available owing to the absence of any adequate system of reporting and analyzing accidents in Iraq, However, it is possible to gain useful knowledge from the records at present available, although not as much as one would wish.

5. Data Analysisand Discussion

Analyzing of accidents data for seven years period (2010 – 2016) was carried outfor Baghdad City. The collected data are listed in **Table 1**.

Table 1: Available Information of Baghdad City.(CSO 2010-2016)

No.	Description
1	No. of Accidents, Fatality and Injuries.
2	No. of Registered Vehicles and Population.
3	No. of Accident as per Type of Accidents.
4	No. of Accident as per Severity.
5	No. of Accident as per Factors.
6	No. of Accident as per Time of Day.
7	No. and Type of Vehicles Involved in Accidents.
8	Age of Drivers Involved in Accidents
9	No. of Fatality and Injuries as per Accident Type.

The trend of RTAs, numbers of registered vehicles and population in Baghdad City during the analyzing period (2010–2016) illustrated in **Fig. 1**, over this period, the numbers of motor vehicles registered and population have increased by 95 percent and 12.1 percent in 2016 compared to 2010 respectively.

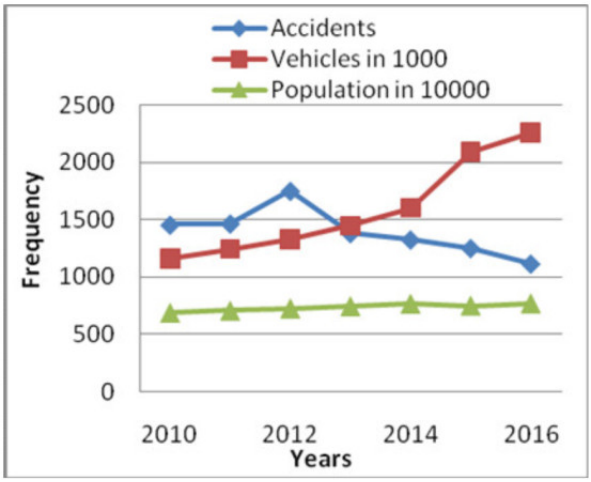

Figure 1: No. of Accidents, Vehicles and population. (CSO 2010-2016)

Over the same period, traffic crashes decreased by 23.5 percent.Where accidents increased to 20.4 percent in 2012 compared to 2010, then decreased to 36.5 percent in 2016 compared to 2012.It can be observed that with huge increase in the number of vehicles, the number of traffic crashes decreases. And this can be attributed to the high traffic volume (no. of vehicles) which leads drivers use their vehicles more carefully by decreasing their speeds.This behavior is agreed with the findings of past studies [11, 15]. The number of fatality, injuries and

crashes present in **Fig. 2.** It is obvious that the trend of injuries similar to the trend of accidents, while trend of fatality is not changed too much during same period. The definition of a road traffic fatality varies from country to country. In the United States, the definition used in the Fatality Analysis Reporting System (FARS) run by the National Highway Traffic Safety Administration (NHTSA) is a person who dies within 30 days of a crash on a US public road involving a vehicle with an engine, the death being the result of the crash [31]. A 12-month rule for counting fatalities is used under World Health Organization procedures adopted for vital statistics reporting inthe United States[5].In the European Union, Greece, Portugal and Spain use 24 hours, France uses 6 days; Italy uses 7 days for counting road accident fatalities [35].Experience indicates that, of the deaths from motor vehicle accidents which occur within 12 months of those accidents, about 99.5 percent occur within 90 days and about 98 percent occur within 30 days [5].

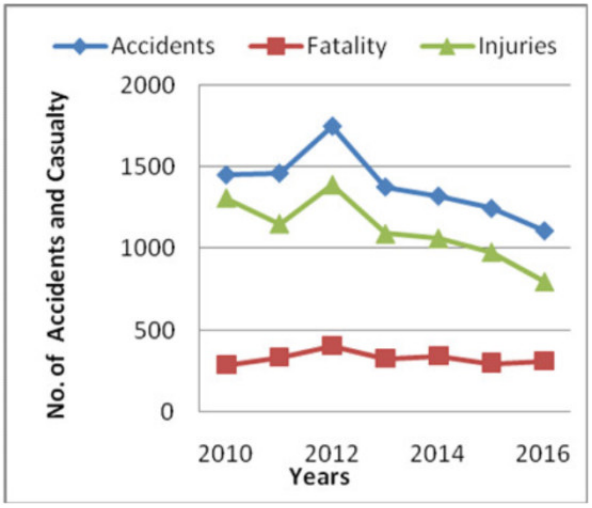

Figure 2: No. of Accidents and Casualty. (CSO 2010-2016)

While the number of fatalities within 30 days tends to be around 1.15 to 1.2 times larger than that of fatalities within 24 hours[41].In Iraq there is no specific period for counting fatality of crashes, where the term "fatality" is normally defined in Iraq as a death within the time of the occurrence of crash only. Therefore, the trend of fatality in Fig. 2does not represent the actual number of crash fatality in Baghdad City because, in many situations, the person who injured in a particular crash and was recorded as an injury case during the time of filling of accident report could dies during the time of transportation from crash location to the nearest hospital (after crash period). On the other hand, the injured person could dies within the first few hours in the hospital due to the severe injury. Fig. 3 shows the number of accidents as per road class for seven years period. As it can be seen arterial roadscomprise most accidents with 53 percent of the total accidents compared to 26, 19 and 2 percent for expressway, collectorroads and local roads respectively. And this can be attributed to high interactive between traffic volume and vulnerable users' volume, and it is confirm with the finding of previous study[6].

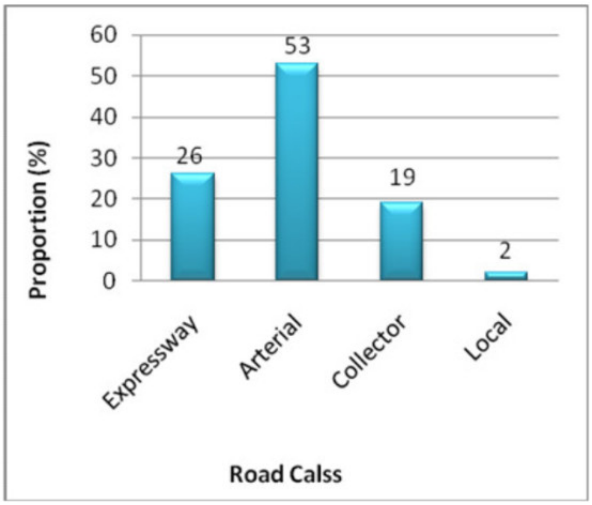

Figure 3: AccidentsAs Per Road Class.(CSO 2010-2016)

In terms of accident types, Fig. 4 illustratedthat maximum accidents are of type run over accidents with 53 percent followed by 40 percent for collision accidents and 7 percent for overturn accidents. Run over crash is classified as a single-vehicle crashes, in which involve collision of one vehicle with pedestrian or cyclists. Therefore, the percent of run over accidents is high because the percent of arterials roads (not access-controlled and high interactive between traffic volume and vulnerable users' volume) accidents is high as stated previously. In others words, most of arterials roads accident involve collision of vehicles with vulnerable users (run over accidents).And this conformsto recent studies, which have shown that pedestrians and motorcyclists have the highest rates of injury in Asia [40, 42, 43].

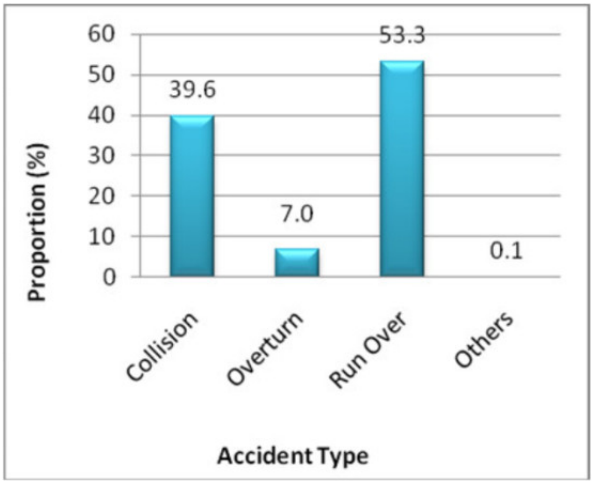

Figure 4: AccidentsAs Per Type.(CSO 2010-2016)

In term of accident severity; the accident is classified according to the most serious injury to any person involved. Fig. 5 illustrated percent of accidents severity. Many scales for ranking crash severity exist; the KABCO scale (used in the HSM), other types of injury severity data

may include detailed information on trauma location and extent of injury; the Abbreviated Injury Scale (AIS), the Organ Injury Scales (OIS) and the Injury Severity Score (ISS) [37]. According to American National Standard, accidents can be classified also by three category set: Fatal accident, Non-fatal injury accident and No injury accident [5]. As it is obvious from Fig. 5, injury crashes is predominant type and constitute more than half of the total crashes.

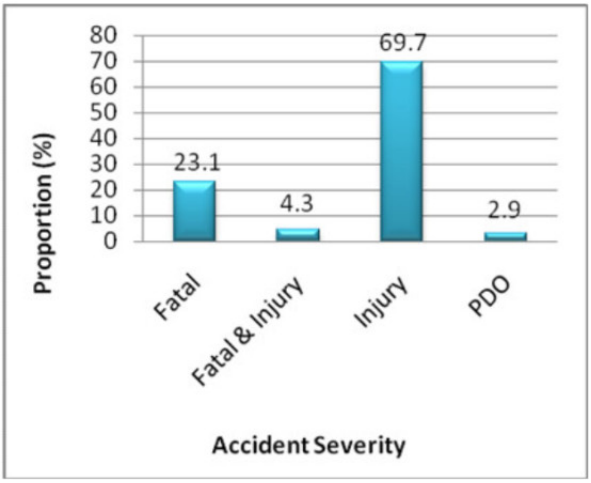

Figure 5: Accidents as Per Severity. (CSO 2010-2016)

Moreover, Fig. 5 shows a 4.3 percent of crashes under Fatal and Injury type and since "crash severity refers to the most severe injury caused by a crash" [19], therefore the term "Fatal and Injury" is incorrect and should be classify as a fatal crash category. As a result, the total fatal crashes are approximately, equal to 27.4 percent of the total crashes.In addition to that, inFig. 5, it can be seen that, the percent of PDO crashes equal to 2.9 during the study period, which is considered very low percent compared to other types of crashes. Therefore, this is evidence that most of the PDO crashes are not recorded.

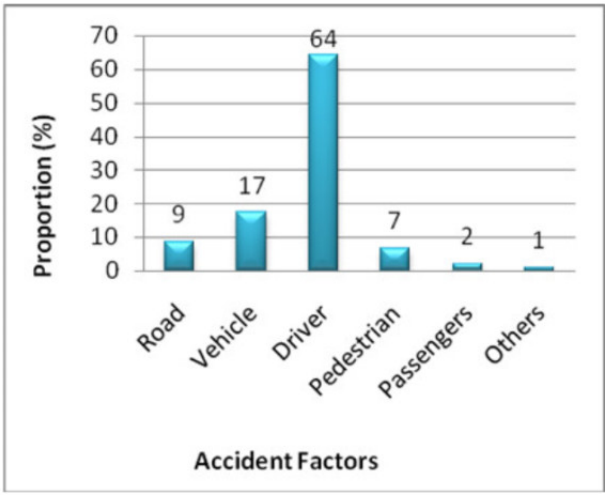

Figure 6: Accident Contributing Factors.(CSO 2010-2016)

As it can be seen from Fig. 6, human factor is the most contributing factor to accidents with 73 percent followed by vehicle factor and road factor with 17 percent and 9 percent respectively. And this may be probably due to inexperience, aggressive driving and inattention (using cell phone). And it confirm with finding of past studies [18, 32]. The concerned authorities should specify and record causes of crashes in details in order to identifying appropriate crash reduction strategies and chose proper countermeasures.Fig. 7shows the distribution of crashes within day.Day time (6 A.M to 6 P.M) had the highest percent of crashes with 58 percent of total crashes, this may be attributed that the working hours of most of government institutes, universities, schools and private companies in Baghdad City are within day time period. And this confirm with the recent studies [7, 16].

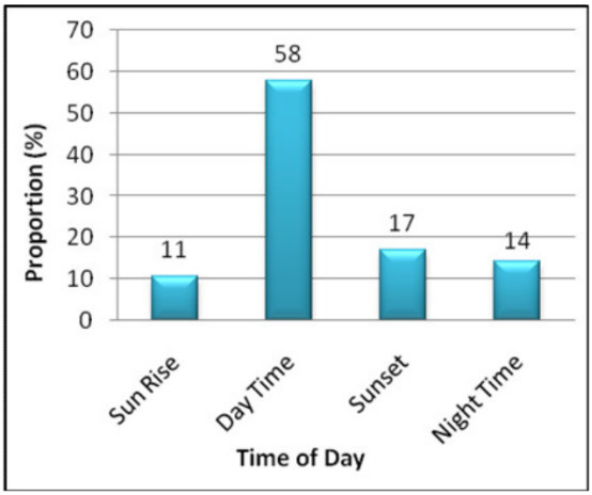

Figure 7: Accidents Time.(CSO 2010-2016)

In terms of type of vehicle involved in accidents, Fig. 8shows that passenger cars are most involved type in accidents with 50 percent followed by buses, sport utility vehicle (SUV) and pick up with 14, 10 and 8 percent respectively. The reason behind high percentage of passenger cars involved in traffic crashes is due to the high motorization level as stated early. The statistical data showed that the passenger cars consists more than half of the total number of registered vehicles in 2015 in Baghdad City.

Moreover, taxi vehicles consists approximate half of the total number of passenger cars, which owned by individuals and not obey to specific institute or private company rules, as unlike others countries, there is no specific taxi system (e.g. taxi stand/station, working hours) in Iraq.However, many studies have shown that taxi drivers are at high risk ofbeing involved in a vehicle crash; [23, 29].

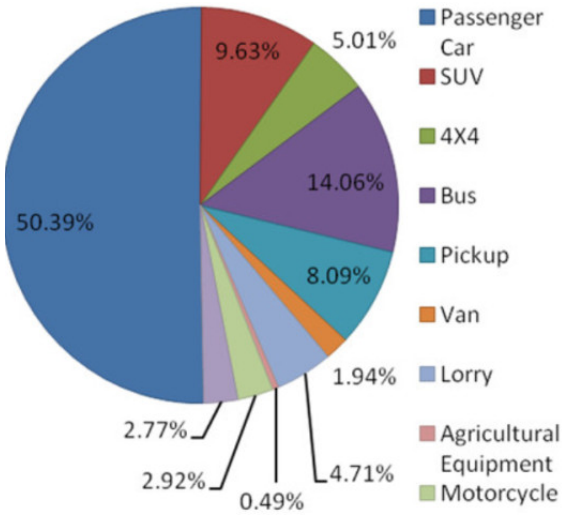

Figure 8: Type of Vehicle Involved In Accidents.(CSO 2010-2016)

Fig. 9illustrates age group of drivers involved in crashes, showing that the age group (24–29) has highest percent among others age groups with 27 percent followed by age group (30-35) and age group (18–23) with 22 percent and 21 percent respectively. It is noted that; young age drivers' are more exposed to crashes than others age groups due to inexperience, aggressive driving, high speed and drinking. And this confirm with other studies [22, 34, 35].

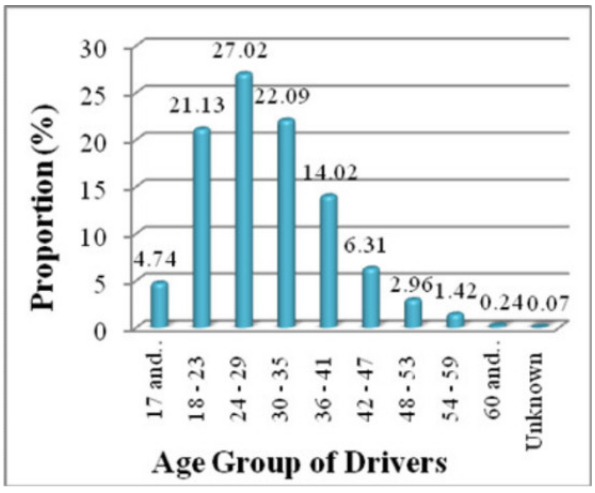

Figure 9: Percent of Age of Drivers Involved In Accidents.(CSO 2010-2016)

In addition to that, in Fig. 9there is an age group (17 and less) younger than the legal age for driving in Iraq (driver get his or her first driving license at 18 years old after passing field test and medical checkup), this age group represent a 4.75 percent from the total percent.In Fig. 10, data information presented for period from 2012 to 2016, because inclusion of tables for these information was done at the beginning of 2012.Fig. 10 shows percent of fatality and injuries as per crash type, and as it can be seen the highest casualty percent are under run over accidents because this type of accidents consistsof collision of vehicle with un-protected vulnerableroad users as stated previously.

Collision accidents types involve second casualty percent, this type of accidents usually consists collision of at least one vehicle with an object or collision of multiple vehicles.

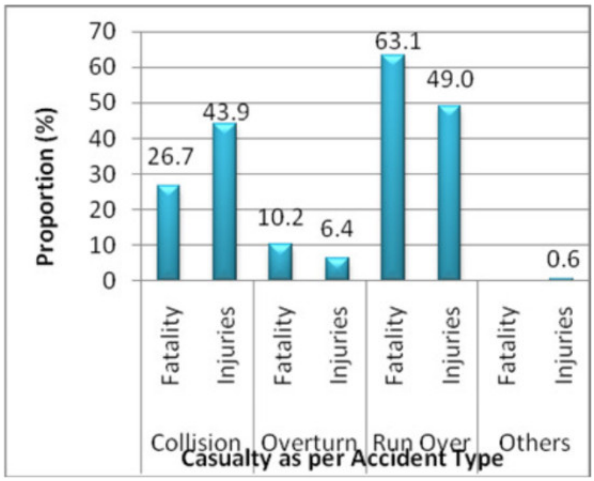

Figure 10: Casualty percent as per Accident Type.(CSO 2010-2016)

It can be notice that the casualty percent of single vehicle accident (overturn crashes plus run over crashes) are much higher than casualty of multiple vehicle collision (collision crashes) even though the collision accidents may be involve single vehicle accident (e.g. collision of vehicle with an object). In another words, the severity of single vehicle accidents is higher than severity of multi-vehicle accidents.

Regarding seatbelt status, inclusion of tables was done at the beginning of 2012 in order to know the seatbelt status for drivers' involved in traffic accidents. Such information is not meaningful, because it is unknown how many drivers dead or injured in a particular crash type also it is unknown the effect of using seat belt on the severity of a particular crash type. Therefore, the available informationregarding seat belt status for drivers involved in crashes is not presented in this study. However, failure to use seat-belts is a major risk factor for vehicle occupants. Paststudies have shown that safety belts reduce the chance of death or serious injury in a crash by almost half. Other studies indicated that in front crashes drivers reported to be using their belts enjoyed an extra margin of protection with air bags [21].

In next section will involve discussion of development of prediction model in Baghdad City using collected data.

6. Development of the Predictive Models

Crash Prediction Models (CPMs) have been used as a useful tool by road engineers and planner. Accidents (Acc) and fatalities (F) in road crashes in a certain country are known to depend upon many factors. Two of them are of high importance namely; population (P) and vehicle kmtraveled. The latter mightbe substituted by the number of registered vehicles (V) if data about distances traveled are notavailable as Smeedand others did [28, 30, 39].Fatalities related to either P or V only might

bemisleading indicator; both factors should be takensimultaneously into consideration. Fatality rate for a country or city in a certain year is the number of fatalities in that year dividedby the number of registered vehicles in the same year (F/V). Motorization level is the number ofvehicles divided by the population (V/P). Table 2 lists accidents, fatality rate and motorization level in Baghdad City for period from 2010 to 2016. The work of Smeed on data from developed countries has shown that, (F/V) the fatality rate per registered vehicle, decreases as the proportion of vehicles in the population increases, this fatality rate varying approximately inversely as the two thirds power of the proportion ofvehicles to the population.

Table 2: Accidents Rate, Fatality Rate andMotorization Level.(CSO 2010-2016)

Year	Acc/V 10000	F/V 10000	V/P 1000
2010	12.54	2.49	277.15
2011	11.78	2.71	287.92
2012	13.20	3.06	297.19
2013	9.54	2.27	313.69
2014	8.27	2.14	335.71
2015	5.98	1.43	440.93
2016	4.92	1.37	463.99

The time series data in Table 2 were used to develop a prediction model for fatality rates and accident ratesfor Baghdad city. The relationship between fatality rates (F/V)and motorization levels (V/P) for the period 2010 - 2016 was not linear (due to the discrete and non-negative integer character of accident/ fatality counts), indicating that Smeed's formula can be applied in Baghdad's case. The first virgin of Smeed's equation assumed the negative exponential form:

$$F/V = a\,(V/P)^{-b} \quad (1)$$

In which (a) and (b) are factors which depend on the domestic conditions of the city or countries that have similar characteristics. (F), (V) and (P) as defined before.The standard regression techniques wereused in order to linearize the relationship andconsequently determine the parameters (a) and (b) equation. The following model was finallyadopted using the statistical package for the social science (SPSS) computer package (version 23):

$$F/V = 8014\,(V/P)^{-1.414}$$

The model was found highly significant with a coefficient of determination (R2) equal to (0.9118).

The residual analysis assured that the model represented the situation well. Fig. 11 shows the relationship between the observed and predicted number of fatalities for the model.

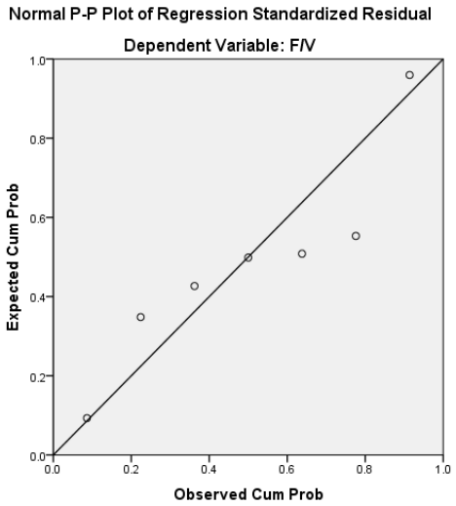

Figure 11: Observed and Predicted Number of Fatalities.

The results are symmetrically clustered around the 45° line to a reasonable extended; which is desirable. Regarding accident rate model, by applying the same process for fatality rate by using accident number (Acc) instead of (F) in Smeed's formula, and also by making use of the time serious data in Table2 the model was finally adopted using the (SPSS) computer package also:

$$Acc/V = 297152\,(V/P)^{-1.788}$$

The model was found highly significant with a coefficient of determination (R2) equal to (0.9483).

The residual analysis assured that the model represented the situation well. Fig.12 shows the relationships between the observed and predicted number of accidents for the model. The results are symmetrically clustered around the 45°line to a reasonable extent: which is desirable. The dispersion of the results from the 45° line is also within acceptable limits.

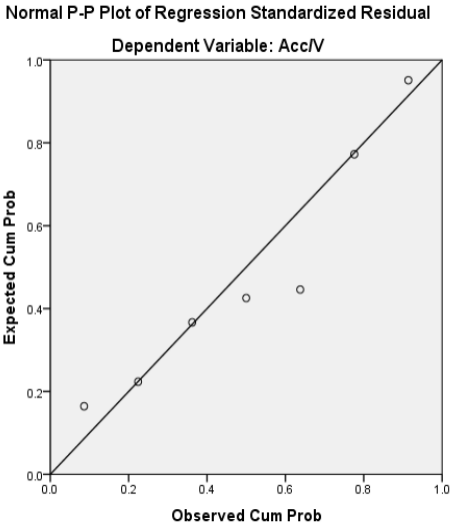

Figure 12: Observed and Predicted Number of Accidents.

7. Conclusion

The major findings from this study are:

1. The CSO records shows a decline in accident trend with huge increase in motorization level, still the loses of crashes considered high where the highest cost of traffic crashes is in the loss of human lives, plus society also bears the consequences of many costs associated with motor vehicle crashes.
2. Approximately 84 percent of the people who die in road accident are the most productive age group (40 ages and younger), furthermoreanalysis shows some drivers younger than the legal age driving in Baghdad City before they get their driving licenses.
3. Highest percent of crashes (53 %) occurred on arterials roads. In addition run over crashesare predominate type on the others types of crashes with 53 percent, furthermore casualty result of this type of crashes is higher than casualty of other types of crashes.
4. The study has also disclosed that drivers are responsible for nearly 64 percent of total accidents. More the half of the crashes occurred within day time.

It is expected that this study provides a framework for development of road safety improvement program in Baghdad City and thus paves the way for improving safety.

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تحليل حوادث الطرق في مدينة بغداد

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الخلاصة – أن حوادث الطرق اصبحت مشكلة عالمية رئيسية في مجالي الصحة العامة والتنمية مما تسبب تكاليف اقتصادية واجتماعية هائلة. لذلك أصبحت حوادث الطرق و تحليل بياناتها مصدر أهتمام أساسي للمحللين من أجل العثورعلى العوامل الرئيسية المتعلقة بالحوادث، والتنبؤ بحوادث الطرق المستقبلية من أجلا لتخفيف منها و / أو القضاءعليها مستقبلا. كشفت الدراسة أن العامل الرئيسي المساهم في الحوادث هو السائق. و أننوع الحوادث السائدة هي حوادث الدهس حيثتشكل 53٪ منإجماليالحوادث. أن مايقارب 53٪ من حوادث الطرق حدثت على الطرق الرئيسية، و 58 ٪ من الحوادث الطرق حدثت خلال النهار، وان السائقين الذين تتراوح أعمارهم بين 24 - 29 عاما هم اكثر اشتراكا في حوادث الطرق، بالاضافة الى ان حوادث المركباتا لمفردة (حوادث الدهس) عادة ما ينتج عنها اصابات خطرة (الوفيات والجرحى) مقارنة مع حوادث المركبات المتعددة (حوادث الاصطدام). أهمال نتائج التيتم الحصول عليها من هذه الدراسة هي إنموذج التنبؤ الذي يربط عدد الحوادث بعدد المركبات المسجلة وعدد السكان.

الكلمات الرئيسية – تحليل الحوادث، إنموذج التنبؤ، مدينة بغداد، بيانات الحوادث.