

CHARACTERISTICS AND ANALYSIS OF ACCIDENTS ON RURAL ROADS (EGYPT AS A CASE STUDY)

خصائص وتحليل الحوادث علي الطرق الخلوية (دراسة حالة الطرق المصرية)

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خلاصة:

يهدف هذا البحث إلى تحليل خصائص الحوادث علي الطرق الخلوية (الطرق المصرية كحالة دراسية، وقد اعتمد البحث في ذلك علي جمع البيانات عن حوادث الطرق مع تصنيفها الي عدد الوفيات والإصابات خلال الفترة من عام ١٩٩٦ حتى عام ٢٠٠٠، حيث تم تجميع بيانات الحوادث مع تصنيفها علي مستوى جمهورية مصر العربية وكذلك علي مستوي كل محافظة بعد تقسيم المحافظات إلى أربعة مجموعات وذلك حسب معدل ملكية السيارات الخاص بمحافظات كل مجموعة . وقد أظهرت نتائج الاستقصاء أن أكبر عدد لملكية السيارات سجلت في محافظة السويس أعلى معدل لها (٣٠٠ عربة/١٠٠٠ مواطن) بينما في محافظة سوهاج أقل معدل لها (١٥ عربة/١٠٠٠ مواطن) كما أظهرت نتائج الاستقصاء علي أن عام ١٩٩٧ سجل أعلى نسبة لكل من عدد الحوادث الكلية وعدد الوفيات والإصابات حيث سجلت عدد الوفيات معدل قدره ٢٦ قتل/١٠٠,٠٠٠ مواطن و ٢٨٠ قتل/١٠٠,٠٠٠ عربة وهذه المعدلات تزيد عن المعدلات المسوح بها في الدول المتقدمة . وفي هذا البحث تم تقدير وتحليل للعلاقة الرياضية Parameters بين عدد الحوادث (حوادث كلية - وفيات - اصابات) و Motorization rate باستخدام أسلوب الرجة الخطية. وقد لوحظ من نتائج تحليل البيانات أنه مع انخفاض معدل الحركة Motorization rate انخفضت معدلات كل من عدد الحوادث بما فيها عدد الوفيات والإصابات وذلك إلى حد معين تزيد بعده معدلات هذه الحوادث رغم انخفاض معدل الحركة Motorization rate حيث تم مقارنة هذه الحوادث بنموذج سميت (Smeed model) لتحديد الفرق بينهما وليكون بمثابة علامة انذار تشير إلى خطورة زيادة عدد الحوادث والاهتمام بالتطبيق الحازم لقواعد المرور علي الطرق المصرية للتقليل من هذه الحوادث وخطورتها .

Abstract

This paper aims to study and analyze the characteristics of road accidents in Egypt, Egyptian Governorate groups and compares the situation of road accidents with that of the other countries. These groups are based on car ownership for governorates. The highest vehicle ownership is found in Suez governorate (about 300 vehicle / 1000 pop.) while the lowest vehicle ownership is found in Sohag (about 15 vehicle / 1000 pop.). Also, the accidents models for Egypt and Egyptian Governorate groups are estimated based on the date collected for accident's number, fatalities, injuries, vehicle ownership and population during the last five years. The highest number of accidents, fatalities and injuries was recorded in 1997. The fatalities rates of Egypt are 26 killed / 100000 pop. and 280 killed / 100000 motor vehicles. These rates are higher than those of the developed countries. In addition, the data analysis proved that high motorization rate is dangerous as the low motorization rate. Average of vehicle of 30-45 vehicle / 1000 pop. is found to be the safest range to keep accidents, fatalities and injuries in minimum levels. The comparison between estimated models and international model has been evaluated to reduce the number of accidents in Egypt.

1. Introduction

In Egypt, traffic congestion on rural roads has steadily increased. Also, road accidents are a rapidly increasing problem in Egypt.

Death, disablement and human suffering are the menacing direct effects on the development of the country which in addition consume scarce economic resources and foreign exchange required for other and better purposes.

Improving highway safety requires consideration of the 3-elements influencing traffic operations; the driver, the vehicle and the roadway. Unfortunately, the traffic engineer has effective control over only one of these elements.

Many theoretical and practical works have been undertaken to study and analyze the road accidents in Egypt and other countries. Moreover, the analysis of road accidents and its characteristics for rural roads in Egypt during the period from 1984 to 1995 had been studied [2, 3].

In addition, the study of the effect of road shoulders width on the safety for rural roads in Egypt has been estimated for Aga - Mit Ghamr road [4].

The analysis of road accidents in Sharkia Governorate and its reduction procedures has been studied. The results of this research proved that the minimum width of local roads is 6.0 m to reduce road accidents [5].

A recent analysis of road accidents in 9 countries in Eastern and Southern Africa has revealed that fatality rates varied from 32 to 124 death per 1000 vehicles in 1983. Moreover, the analysis revealed that the number of deaths caused by road accidents in 1983 varied between 4 and 28 per 100000 inhabitants in the nine countries [6].

Table (1) shows the number of killed persons through the road accidents in several countries [7].

Table 1 Persons killed / population and vehicles in different countries [7]

Country	Ethiopia	France	Nigeria	Norway	Kenya	South Africa	Sweden	UK	USA
Killed/ 100000 Pop.	3	24	11	10	15	37	9	11	19
Killed/ 100000 Motor vehicle	1710	65	2650	30	1570	240	26	38	35

In Saudi Arabia, a comparative analytical study on road accidents had been reviewed [8].

A recent research was carried out to develop accidents modeling technique the non-parametric model – that predicts accidents rate as a function of geometric design elements, traffic flow parameters, and the roadside activities.

Cairo-Alexandria Agricultural road was considered for data collection. The non-parametric model results indicate that it overcomes some of the shortcomings of the most common methods of analysis (regression and discriminant) [9].

The objectives of this paper are:

- 1) To discuss the magnitude of road accidents for some governorates in Egypt during the last 5 years and to compare the situation of the road accidents with that of the other countries.
- 2) To analyze road accidents and establish the road accidents prediction models for classified groups of governorates based on the vehicle ownership and population.

2. Data collection procedures

In this research work, data has been collected for whole Egypt and some governorates during 1996 till 2000 of the following [10, 11]: population, motor vehicles, number of accidents, fatalities numbers, and injuries numbers.

Moreover, Egyptian governorates are classified into four groups based on the private car ownership as follows:

Group A: which has private car ownership ≥ 45 vehicles/1000 pop. This group includes Cairo and Alexandria. Cairo is the capital, the center of business, works, education and almost all public affairs. Also, Alexandria is the second city and main port of Egypt.

Group B: which has private car ownership lies between $\geq 30-45$ vehicles/1000 pop. This group includes Giza, Suez and Port Said. Giza is the center of all modes of transport to Upper Egypt. Suez and Port Said are ports on the Mediterranean Sea and centers for the some industries related to the sea.

Group C: which has private car ownership lies between $\geq 10-30$ vehicles/1000 pop. This group includes Damietta, Dakahlia, Qalyubia, Gharbia, West Desert (Matruh), Red Sea, Ismailia and North Sinai.

Group D: which has private car ownership < 10 vehicles/1000 pop. This group includes New Valley, Aswan, Qena, Sohag, El-Minya, Fayoum, Beni-Suef, Assiut, Beheria, Minufia, Kafr El-Sheikh and Sharkia.

3. Calculation Background

The works of Smeed on data from developed countries have shown that there were tendencies for fatality rates per vehicle to decrease and per person to increase over time. Smeed model represents the trend for fatality rate per vehicle in the following formula [8]:

$$F/V = \alpha (V/P)^{\beta} \quad \dots(1)$$

Where: V = Number of registered vehicles.
 F = Number of Fatalities
 P = Number of population

α, β = Constants.

For accidents and injuries, a direct relationship is related to motorization rate in the following formula [8]:

$$\text{Acc} = \alpha_1 (V/P)^{\beta_1} \quad \dots(2)$$

$$\text{INI} = \alpha_2 (V/P)^{\beta_2} \quad \dots(3)$$

A regression technique is employed to estimate the parameters of the above equations.

The linear transformation of each equation was first obtained by taking its logarithm, and then regressed to give the prediction model as follows [8]:

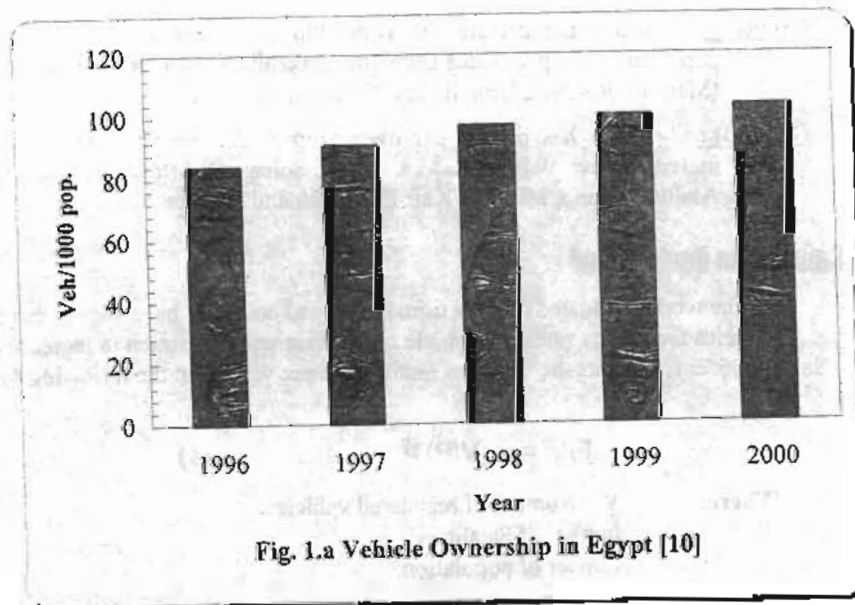
$$\text{Log}(F/V) = \text{Log } \alpha (V/P)^{\beta}$$

$$\text{Log}(F/V) = \text{Log } \alpha - \beta \text{Log}(V/P) \quad \dots(4)$$

4. Analysis of Accidentants

4.1. Analysis of Accidents for Egypt

Fig.1. shows vehicle ownership (number of vehicle/1000 pop.), accident, injuries and fatalities trend over the last five years 1996 – 2000 in Egypt [10, 11].



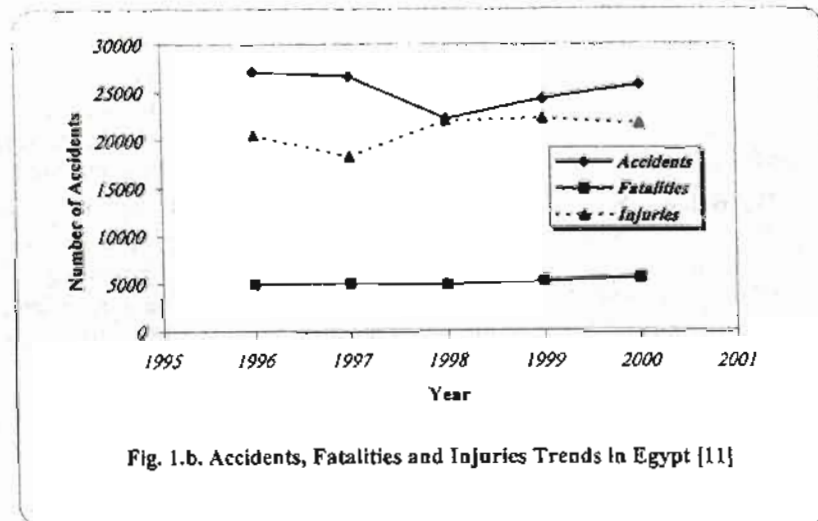


Fig. 1.b. Accidents, Fatalities and Injuries Trends in Egypt [11]

Fig. 1. reveals that there are rapidly increase in the vehicle ownership and injuries, rapidly decrease in the total accidents during the three years 1996 – 1998. For the next two years, while the vehicle ownership and total accidents slightly increase, injuries decrease.

However, there is no significant difference in fatalities over the study period. Also, the fatalities rates of Egypt are 26 killed / 100000 pop. And 280 killed / 100000 motor vehicles. These rates are higher than those of the developed countries as indicated by table 1.

4.2. Analysis of Accidents for Governorates

Vehicle Ownership analysis shows a rapidly increase during the period 1996 – 1998 for the groups A, B and it shows a slightly increase during the period 1999 – 2000 for the groups A, B and during the 1996 -- 2000 for the groups C and D as indicated by Fig 2. However, some governorates have a decrease in vehicle ownership in 2000 like *N. Sinai, Aswan and Minya*, while others show no change like *Sohag and Ismalia*. This rapid growth in the vehicle ownership is due to the application of privacy economic system in the last two years. Therefore, it can be concluded that vehicle ownership has the same trend for the whole country as well as for the same governorates. Moreover, the highest vehicle ownership is found in Suez governorate (about 300 vehicle / 1000 pop.) while the lowest vehicle ownership is found in Sohag (about 15 veh. /1000 pop.).

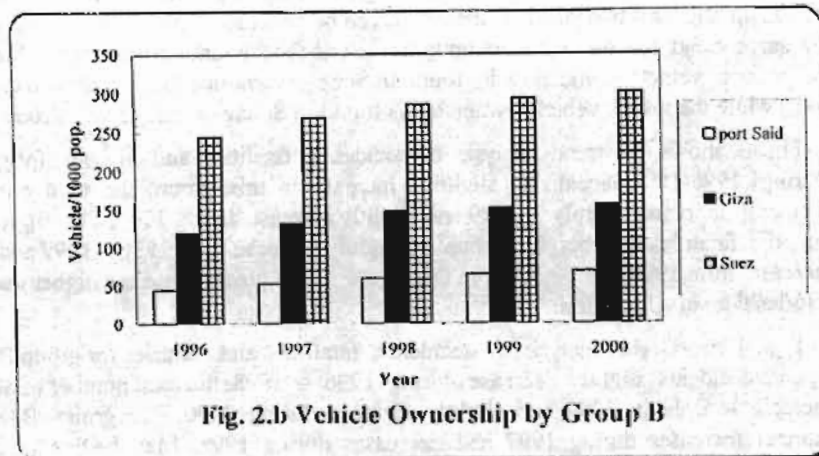
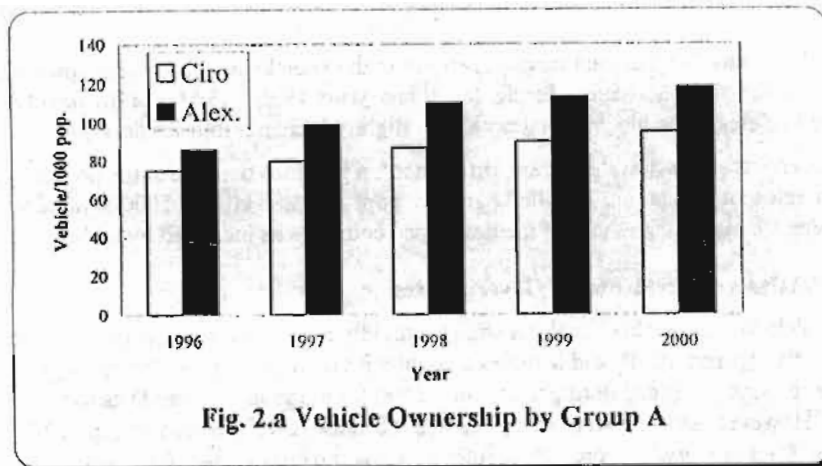
Fig. 3 shows the trend analysis of accidents, fatalities and injuries for group A. During 1996-1998 accidents slightly increase in this group, the total number of accidents increases sharply in 1999 and slightly increase during 2000. This figure shows that the fatalities number for group A slightly increase from 1996 – 1997 and rapidly increase from 1998 – 2000. Also, in this figure, Cairo governorate has higher number of injuries than in Alexandria.

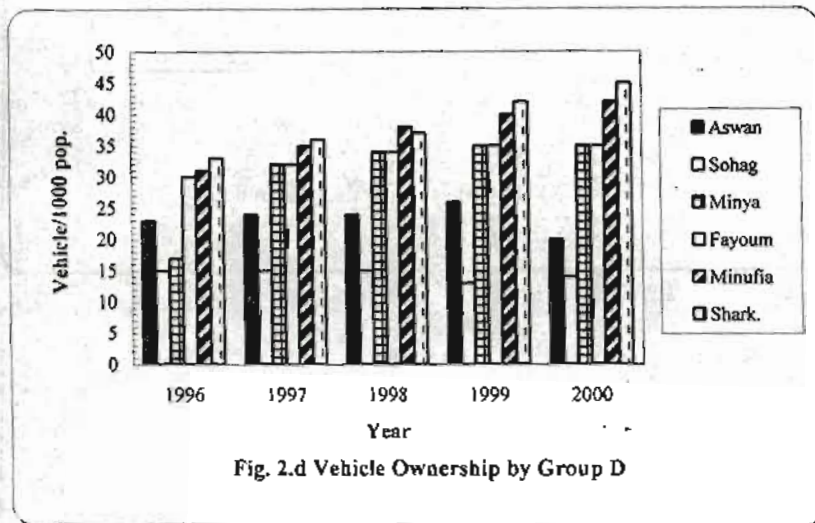
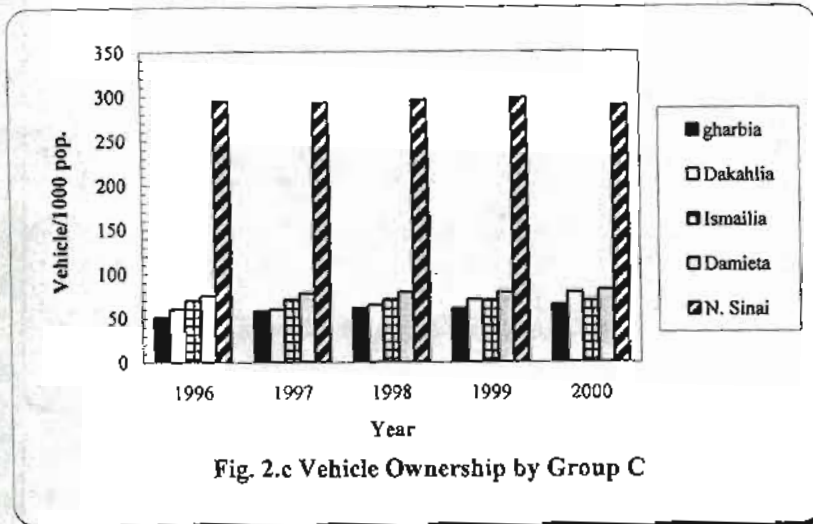
Fig. 4 shows the analysis of accidents, fatalities and injuries for group B. In this figure, accidents slightly decrease during 1996 – 1998, the total number of accidents increase sharply in 1999 and slightly increase during 2000. For group B, fatalities number increases during 1997 and decreases during 1998. May be this reduction of fatalities number is related to a good and strong control of roads in this group. Also, in this figure Giza has higher injuries number than those of Port Said and Suez.

Fig. 5 shows the analysis of accidents, fatalities and injuries for group C. In this figure, three governorates suffer high accidents, Dakahlia, Gharbia and Qaliubia with respect to the rest governorates of this group. Also, these governorates represent highest number of fatalities and injuries, while Damietta and Ismailia have medium number.

Fig. 6 shows the trend analysis of accidents, fatalities and injuries for group D. In this group, Sharkia, Minufia and Fayoum governorates have high accidents with respect to the rest of this group. Also, these governorates suffer from increasing the number of fatalities, therefore, the roads of these governorates are in great need of full control and improvement. The fatalities of this figure lies between 400 – 1000 persons. In this figure, the injuries are within average between 300 – 1800 persons.

Finally, it can be noted from the analysis of the previous figures that there is no obvious trend for accidents over the study years. Moreover, year 1997 has the highest number of accidents, fatalities, and injuries over the study period.





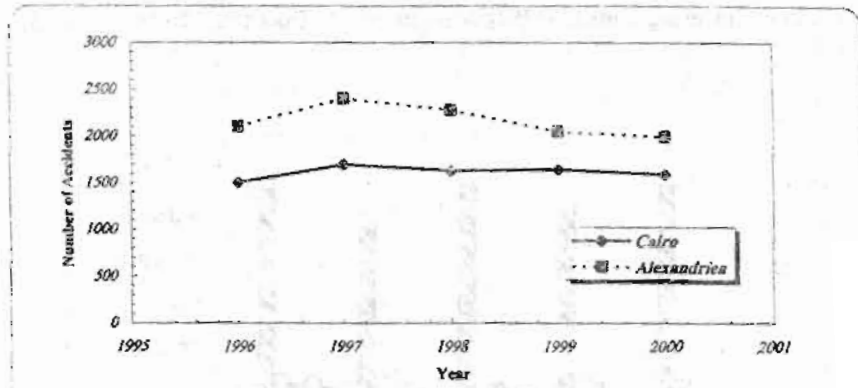


Fig. 3.a. Accidents Analysis by Group A

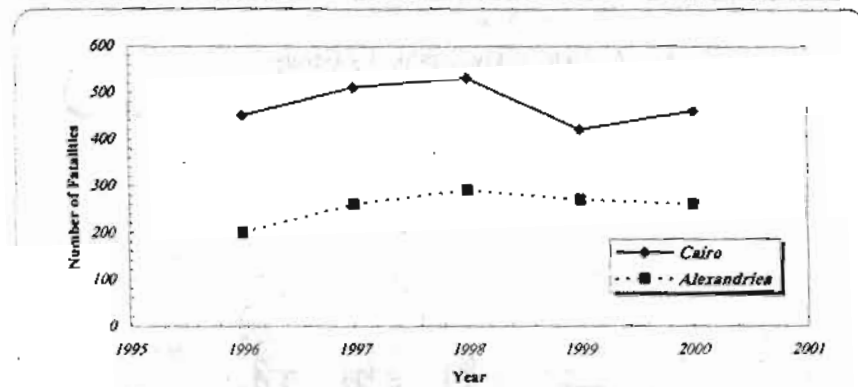


Fig. 3.b. Fatalities Analysis by Group A

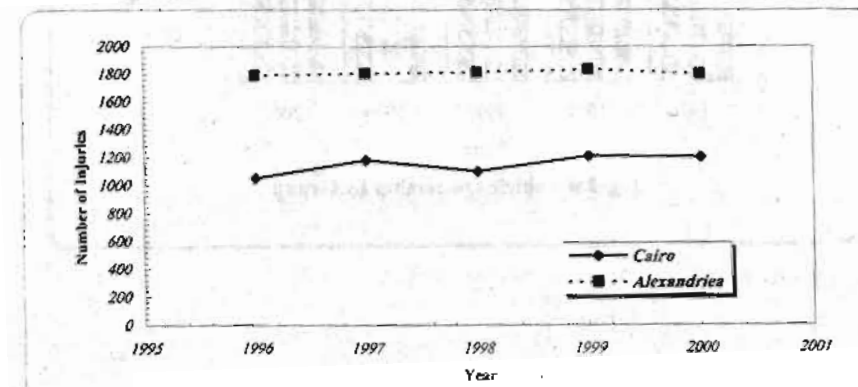
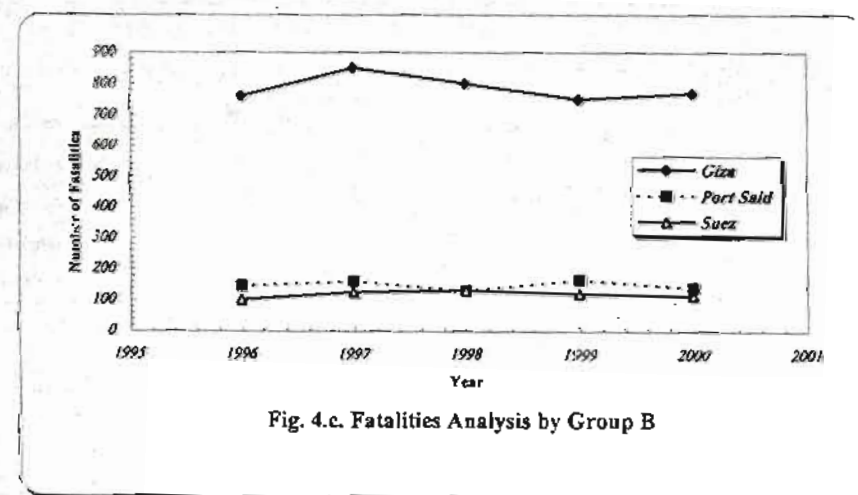
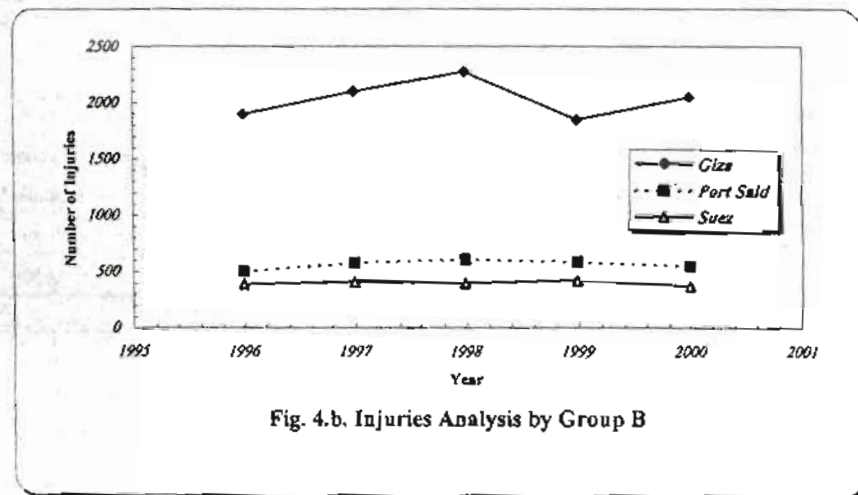
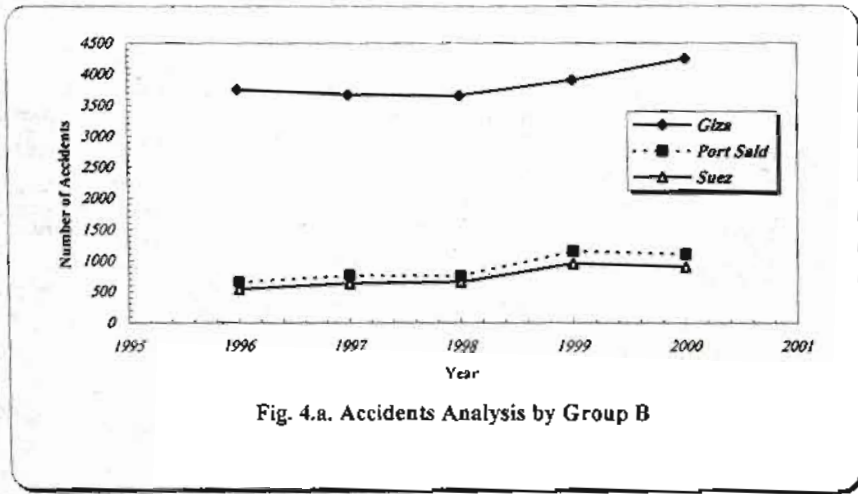


Fig. 3.c. Injuries Analysis by Group A



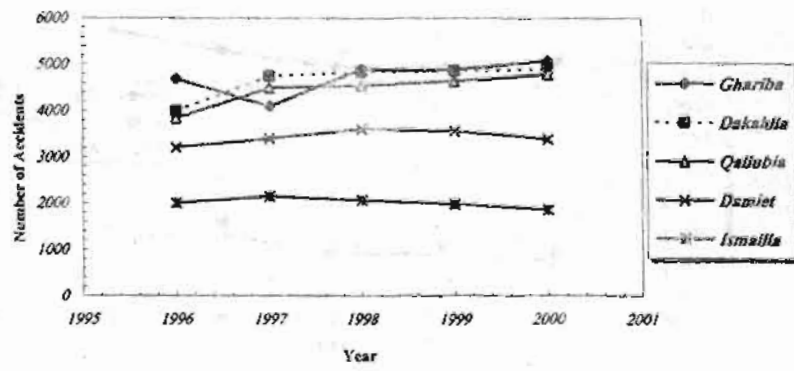


Fig. 5.a. Accedients Analysis by Group C

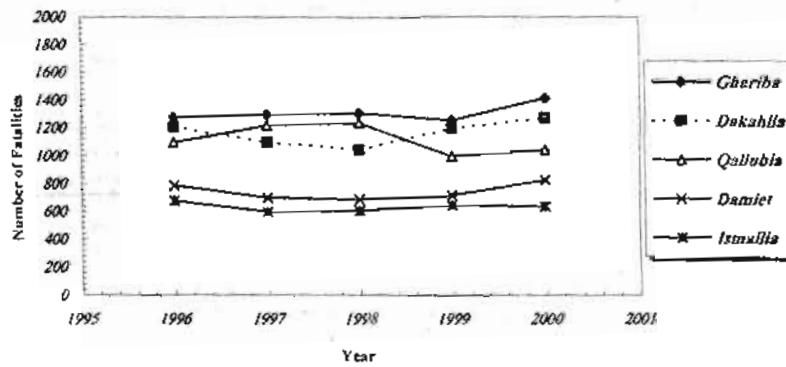


Fig. 5.b. Fatalities Analysis by Group C

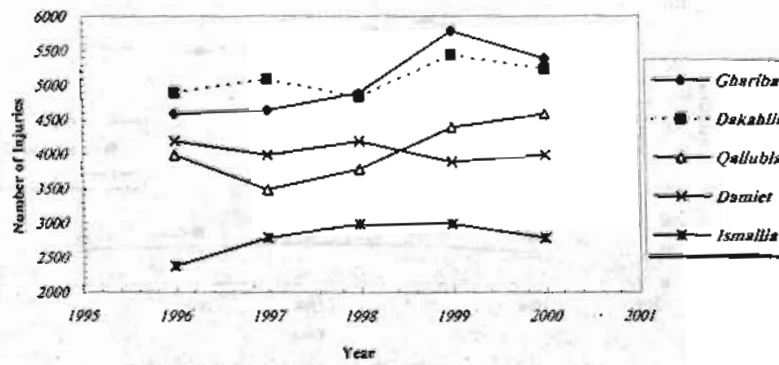
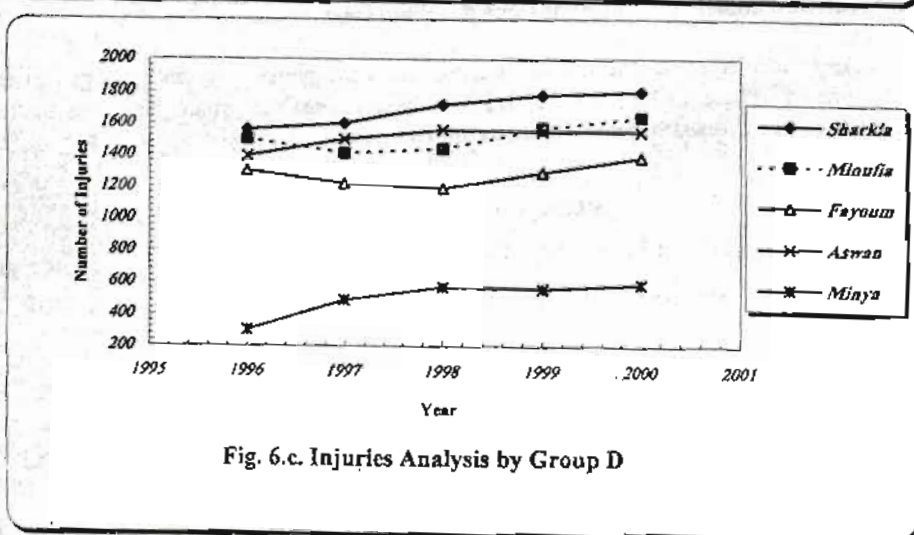
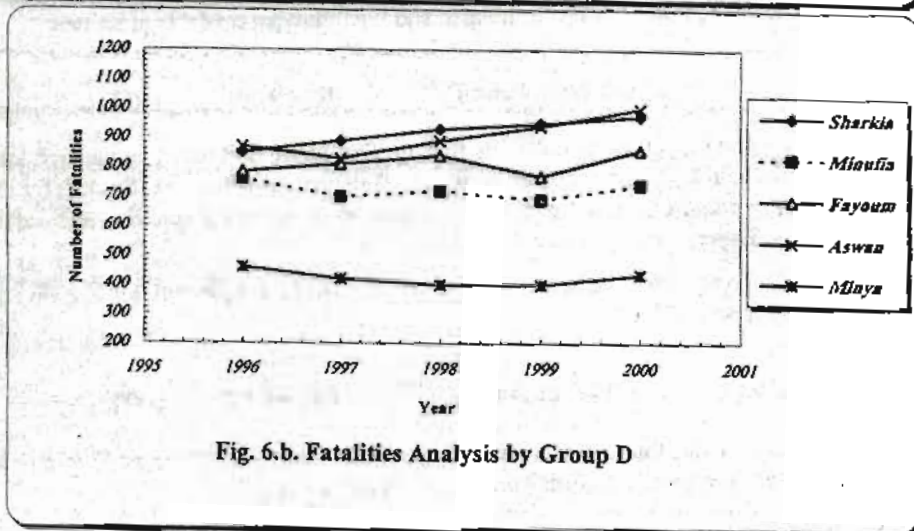
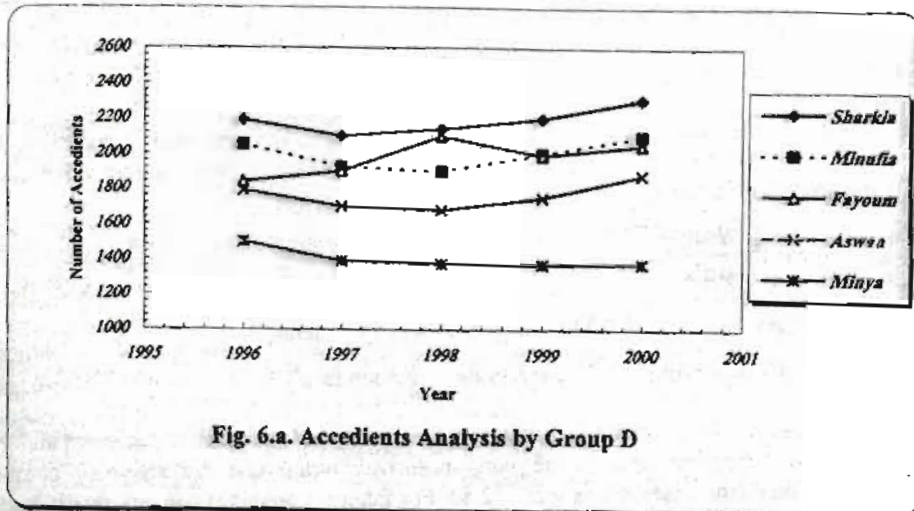


Fig. 5.c. Injuries Analysis by Group C



5. Accidents prediction models

5.1. Egypt Prediction Model

Based on the data collected for accidents, fatalities, vehicles, and population, the following models are estimated and fitted by regression analysis. For accident model, the produced formula is:

$$ACC = \left\{ \frac{Veh.}{pop.} \right\}^{2.53} \quad (R^2 = 0.90) \quad \dots (5)$$

Where: ACC. = The yearly number of accidents.

(Veh. / pop.) = The yearly motorization rate

The model reveals a strong correlation between the yearly number of accidents and the yearly motorization rate. As the yearly motorization rate increases, the yearly number of accidents increases in a power of 2.53. For fatalities prediction model, fatalities per 1000 vehicles measure (F/V) is formulated and the following model is presented,

$$(Fat. / veh.) = 0.0021 (veh. / pop.)^{-0.991} \quad (R^2 = 0.90) \quad \dots(6)$$

Comparing the Egyptian model with that of Smeed. It is found that the produced model in equation (6) has higher constants than that produced by Smeed for the developing countries. This reflects the urgent necessity for improving the safety situation in Egypt.

For injuries per 1000 vehicles, the model estimated in Egypt in relation to the motorization is as follows:

$$(Inj. / veh.) = 0.0041 (veh. / pop.)^{1.183} \quad (R^2 = 0.90) \quad \dots(7)$$

The model reveals that injuries per 1000 vehicle increases at the motorization rate increases in a power of 1.183 and correlation coefficient of 0.90.

5.2. Prediction models by groups of some governorates:

Yearly Accidents, fatalities and injuries models for Egyptian Governorates groups are estimated. These models are yielded to power regression, which have a statistical significance and a strong correlation as follows:

$$ACC = (Veh. / pop.)^a \quad \dots (8)$$

$$Inj = (Veh. / pop.)^b \quad \dots (9)$$

$$Fat = (Veh. / pop.)^c \quad \dots (10)$$

Where a , b and c are the models constants presented in Table 2. The table also shows the correlation coefficient and the level of significance for each model.

Table 2: Accidents, Injuries and Fatalities Models Constants For Some Egyptian Groups Of Some Governorates.

Group	P. Car ownership	Parameters	R ²	T - Value	P - Value
A	≥ 45	a = 1.669	0.98	93.422	0.000
		b = 2.024	0.98	94.609	0.000
		c = 1.508	0.98	91.225	0.000
B	≥ 30 - 45	a = 1.246	0.89	10.017	0.000
		b = 1.277	0.95	18.453	0.000
		c = 0.921	0.91	13.751	0.000
C	≥ 10 - 30	a = 1.492	0.91	24.692	0.000
		b = 1.461	0.94	30.873	0.000
		c = 1.167	0.91	24.405	0.000
D	< 10	a = 2.108	0.935	31.857	0.000
		b = 1.466	0.90	26.446	0.000
		c = 1.585	0.87	22.709	0.000

In the above models, number of accidents, injuries and fatalities are related directly to the motorization rate instead of accidents / 1000 vehicles which show insignificance in the model formulation. It is also noted during the analysis stage that there is no significance difference between accidents data of group A.

The third column of the table reflects the worst safety situation on the governorate level in many points of view. Firstly, the high power of the prediction models. Secondly, there is a higher degree of danger associated with accidents occurrence. This means that for the same motorization rate, fatalities and accidents number are approximately equal in some groups like group A and D. It is also found that for group B and C, accidents numbers and injuries have approximately the same value at the same motorization rate as indicated by models. Moreover, group A,D have the highest number of accidents, injuries and fatalities while, group B has the lowest numbers.

It is also noted that the powers of the models (a , b , c) decrease from group A and group B and then increase gradually in group C and D. This means that as the motorization rate decreases, the number of accidents, fatalities and injuries decreases to its lowest value and then increases again with the motorization rate decrease. Therefore, high motorization rate is dangerous as the low motorization rate. A range of

vehicle of 30 – 45 veh / 1000 pop. is found to be the safest range to keep accidents, fatalities and injuries in minimum levels.

6. Models Validation

After constructing accidents, fatalities, and injuries models for Egypt and some governorate groups, the model performance have been verified. This was accomplished by comparing the results estimated by these models with those obtained from the observations. The errors between calculated and observed date are $\pm 1\%$ as a minimum value and $\pm 15\%$ as a maximum value for all models described from equation 5 till equation 10. For example, the error between calculated and observed accidents number in 2000 for Cairo and Alexandria governorates are 3.2% and 2.4% respectively. The corresponding error for fatalities and injuries are 6.4% & -2% for Cairo governorate and 2.2% & -7% for Alexandria governorate as shown in table (3).

Thus, the models are verified and can be applied to similar studies by changing parameters to the conditions required.

Table 3: Error percent between calculated and observed accidents, fatalities and injuries number in year 2000

Error between calculated and observed	Cairo	Alexandria
Accidents %	3.2	2.40
Fatalities %	6.4	2.2
Injuries %	-2.0	-7.0

7. Conclusions

This paper studied and analyzed the characteristics and magnitude of road accidents in Egypt as a total and some governorates.

This study was based on the collected data of accidents, fatalities, injuries, population, and vehicle ownership during the last five years. The analysis of the data was operated by using the regression analysis. The main results can be reported as follows:

1. The highest vehicle ownership is found in Suez governorate (about 300 vehicle / 1000 pop.) while the lowest vehicle ownership is found in Sohag (about 15 vehicle / 1000 pop.).
2. Year 1997 has the highest number of accidents, fatalities and injuries.
3. The fatalities rates of Egypt are 26 killed / 100000 pop. and 280 killed / 100000 motor vehicles. These rates are higher than those of the developed countries.

4. As the motorization rate decrease, accidents number, fatalities and injuries decrease, to its lowest value and then increase again with the motorization rate decrease. Therefore, high motorization rate is dangerous as the low motorization rate.
5. A range 30 – 45 veh. / 1000 pop. is found to be the safest range to keep accidents, fatalities, and injuries number at minimum value.
6. The produced models of accidents, fatalities and injuries are yielded to the power regression equations.
7. A Comparison between Egypt models of accidents and Smeed model proved that there is a difference of constants between them. This give us a warning sign to apply a strike traffic control on Egyptian roads to reduce the number of accidents.

8. References:

- 1- William R. Mcshane , Roger P. Roess, Traffic Engineering Prentice Hall, Englewood cliffs, New Jersey, 1990.
- 2- The Egyptian Academy of Scientific and Technology “ Accidents Study on Urban and Rural Highways”, Report No. 1-6 , 1990.
- 3- Abdalla H. Whdan and Mona H. Abd Allah, “Analysis and Modeling of road accidents in Egypt” Engineering Research journal (ERJ) ,university of Helwan, 1997.
- 4 – El- Sayed ShawaLY, El- Shourbagy ,M., “Effect of road shoulders widths on the Safety for Rural Roads (Aga – Mit Ghamr Road)” , Arab Road Magazine , 42nd year, 3rd Edition , 1994 .
- 5 – M. Gouda Mohamed, “Analysis of Road accidents in Sharkia Governorat” Arab Road Magazine/ 4th Year , 1st Edition , 1996 .
- 6- Heming Lauridsen and Richard Muskaug , “ The Current Situation And Problems of Road Safety in Africa”, 1st African Road Safety Congress, Nairobi , Kenya , 27-30 , August , 1984.
- 7- Gunnar Slagnes , “ Traffic Accident Situation in Norway “, 1st African Road Safety Congress , Nairobi , Kenya , 27-30 August , 1984 .
- 8- Sharf E., “ Road Accidents in Saudi Arabia , A comparative and Analytical Study” Sci. Bull. Fac. Eng. Ain Shams Univ., Vol. 31, No. 1, March 1996, ISSN 1110-1385.
- 9- Mona H. Abd Allah, “Model to determine the effect of Speed on Traffic Accidents”, Ph.D. Thesis, Ain Shams University, 1993.
- 10- Ministry of Interior, General Department of Traffic, Annual Statistics, 2000.
- 11- الإدارة العامة للمرور ، رابعه العدويه ، مدينة نصر ، مايو ٢٠٠١