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# ANALYSIS AND MODELING OF TRAFFIC ACCIDENTS CAUSES FOR MAIN RURAL ROADS IN EGYPT

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*The purpose of this research is to investigate traffic accidents causes and major factors that would be the main reasons for accidents, and to develop a model for accidents on Main National Egyptian Rural Roads. Accidents models would help decision makers to develop the road network to be more safe and minimize the accidents rate. Models were calibrated using accidents records data collected from 19 rural roads from previous studies, and 7 rural roads from filed surveys in Assiut region, "General Authority for Roads & Bridges". The data was splittied in two different types of road sections in location and engineering properties, namely; "Agriculture roads undivided sections", "Desert roads undivided sections". Simple, Stepwise, and multiple regression analysis have been used to find the effect of each parameter on the accident rate value. Several functional forms are explored and tested in the calibration process. Before proceeding to the development of models, ANOVA statistical tests are conducted to establish whether there are any significant differences in the data used for models' calibration as a result of differences among the considered roads. The results indicated that exponential model formula represents the highest correlation for all road types .Average daily traffic (ADT), Shoulder width, pedestrian crossing and percentage of trucks have highest effects of traffic accidents on agriculture roads undivided sections, Shoulder width, Radius of horizontal curves and percentage of trucks have the highest effects of traffic accidents on desert roads undivided sections.*

***KEYWORDS:*** *Accident, Modeling, Analysis, Road safety, Rural road.*

## 1- INTRODUCTION

Traffic accident is an expression used to describe a certain failure in the performance of one or more of the traffic system. These include the driver, the vehicle, pedestrians and the roadway geometry. Accidents may cause death, injury, and/or property damage. The property damage accidents are resulting destructive effect on vehicles involved in the accident and/or the road elements. Traffic safety is a function of quality of traffic management, geometric design, roadway illumination, roadside features, maintenance, enforcement, traffic control devices, and traffic operation [1].

Traffic accident problem disturbs the majority of people all over the world. Where, About 1.27 million people are killed as a result of road accidents in the world every year [2]. There are about 20 to 50 million victims as a result of accidents per year and that more than 90% of road traffic deaths occur in low-income and middle-income countries. In these countries the most vulnerable are pedestrians, cyclists, users of motorized two- and three-wheelers and passengers on unsafe public transport [3].

The effects of road accidents include loss of life, health damage, social impact on the families of the victims and damage of vehicles i.e. damage in the economy. Decision makers and highway officials need accurate information about the relationships between accidents and its causes. Therefore, researches all over the world study traffic accidents to demonstrate their causes and reduce their harmful effects. Traffic safety has become one of the major public concerns in day-to-day life. With the constantly growing traffic volumes and limited resources for road infrastructure, efficient method of safety improvement becomes increasingly important.

In Egypt, about 156 persons die per 100000 vehicles in 2006. This rate is the highest in the world compared to other countries where the rate is 73 in Turkey 29 in Greece, 13 in Italy and 9 in Switzerland [4], [5].

The following subsection describes the factors influencing traffic accidents frequency and severity as reviewed in the literature.

In Egypt, Human factors represent driver ability to control the vehicle, determines the probability of accident occurrence, and crossing error for pedestrian. These factors are responsible for about 74% of accident occurrence, Vehicles are responsible of 17% of accident occurrence. Also Road characteristics such as road design elements, maintenance conditions, land use and weather contribute 9 % in accidents occurrence [6].

The driver ability is affected by age, sex, attitudes, roadway characteristics, and vehicle's condition. Males are involved in accident occurrence more than females. Age also has high effect on accidents. The age < 30 years old is the most serious age group on accident occurrence. And also that effective traffic control devices must be visible, recognizable, understandable, and necessary. Side markings of pavement' edges, and between lanes and directions give required limitations to the drivers using the road space especially at night. Surface conditions (The presence of distresses in highway surface) may cause interruption to the driver and consequently affect safety level. These distresses may include alligator cracks, rutting, pothole, bleeding. Other pavement and surface condition factors that include road skid resistance and wet road surface are also important [1].

Pavement width affects accident rates (AR). A reduction in accident rate of about 50% is attained when pavement width is increased from 7.0 to 10.0-meters for agriculture roads undivided sections. Also average daily traffic volume (veh/day) affects accidents rate (AR) [7].

Shoulder Width affects accident rates (AR). A reduction in accident rate of about 37 % is reached due to widening shoulder by 1-3 meters in on agriculture roads undivided sections. And also percentage of trucks and buses reduces the level of service on the road. As a result, the probability of accident occurrence increases. Decreasing percentage of trucks by 10 % reduce accident rate about 18 % for agriculture road undivided section [8].

Median width is the least signification characteristics correlated to traffic hazarded, but the general trend obtained from simple regression analysis indicated that median width is inversely proportional to property Damage-only Accident per million vehicle kilometer (EPDO-Rate) [9].

Horizontal curves are the place where 10-12% of all accidents are concentrated. The results concluded that the number of accidents on curves increase with a decrease in their radii [10]. Existence of entrances to the road increases the number of conflict points. This increases the possibility of accident occurrence [11].

Developing accident models can help in predicting accidents effectively and allow decision makers to provide road safety measures. Most statistical technique used in accident modeling is the multiple linear regression models that give simple models which present the correlation between accident rates and the factors affecting it.

The following subsections explain the models used for accident modeling. It also provides some examples of these techniques.

It is assumed that accidents occurring on a particular roadway or at a particular intersection are independent from one to another. So that certain mean number of accidents per unit time is characteristic of a given site and other sites with the same properties. The accidents mean itself is assumed to be dependent on highway variables. Therefore, the mean must be greater than zero. It is taken to have a generalized linear form given by Vogt, A. and Bared [12].

$$\mu_i = \mathrm{Exp}(\beta_0 + \sum_{j=1}^{n} x_{ij}\, \beta_j) \qquad \text{……………………………………………} (1)$$

Where:

$\mu_i$ = The mean number of accident to be expected at site i in a given time period.

$x_{ij}$ = The values of the highway variables at site number i during that time period.

$\beta_j$ = Coefficients to be estimated by the modeling.

On two-lane local rural roads, due to the low traffic volume and to the lack of a significant number of accidents, it is necessary to divide roads into homogeneous sections with a minimum length in order to develop valuable Accident Prediction Models(2) [13].

$E(Y) = e^{a1} . L .AADT^{a2} .e^{\Sigma(bj .}$ (acc/year) ………………………………...…..……… (2)

Where:

E(Y) = Expected accident frequency /1 years of the random variable Y

L = Length of the segment under consideration (km)

AADT = Average Annual Daily Traffic (AADT) (veh/day)

$x_j$ = Any additional variables in the model.

$a_i$, $b_j$ = Model parameters;

Different types of accident frequency prediction models based on AADT and other variables were developed in there study [14] shown in Model (3).

$E(A) = a . ADT^b . e^{c\,x}$ ……………………….. …………… (3)

Where:

E(A) = Number of pavement related accidents per year for one direction of travel

a, b, c = regression coefficients to be determined from the data,

ADT = average daily traffic volume per lane in each highway segment (vehicle/day),

x = explanatory variables

In Egypt, there are many traffic accident studies; each study has models about typical region location.

A study [9], concluded a linear model to forecast road accidents in Egypt from studying five roads, in terms of property damage accident unit, per million vehicle-kilometer (EDPO-RATE), reached model, is shown in table(1), Model(4). Another study [7] concluded a power model to forecast road accidents for Main Roads Network of Dakahlia Governorate from studying five roads, in terms of accident rate unit, per million vehicle-kilometer (AR), reached model is shown in table(1) Model(5). Another study [8], concluded a general model to forecast road accidents in upper Egypt from studying two roads, in terms of accident rate unit, per million vehicle-kilometer (AR), reached models is shown in table (1) Model (6).

Table (1) Models of traffic accident for undivided agriculture roads in Egypt

| Ref. | Road type | Model |
|---|---|---|
| [9] | all types | EDPO-RATE=0.0593+0.0748*(R-obs)+0.0438*CP +0.0058*CL +0.000026*HDT-0.001*ADT +0.0035*P +0.1091*M +0.0227*SW<br>$R^2$=0.837 ………………….(4) |
| [7] | undivided | AR=11.946-1.1556*$P^{0.9}$-4.77897*$SW^{5.5}$-0.000046*$ADT^{4.5}$-0.009913*$HVT^{7.5}$ +5.083355*SCH<br>$R^2$=0.876 …………………..(5) |
| [8] | undivided | AR=0.12+$SW^{-2.42}$+ $e^{0.24CP}$ + $HDT^{20.61}$<br>$R^2$=0.874 ………………….. (6) |

Where:

AR = accident rate (accident /Million vehicle -Kilometer)
EDPO-RATE = Property Damage-Only Accident per million vehicle kilometer
HDT = percentage of truck and buses and slow vehicle (%)
P = pavement width of one direction in meter
SW = shoulder width for one side in meter
ADT = average daily traffic (vehicle/day)*$10^{-3}$
HVT = Heavy vehicle daily traffic volume (heavy veh./day)* $10^{-3}$
CL = percentage of curve length per km (CL /km %)
R-obs = Road side obstructions (obs/Km)
SCH = Existing schools (1 if present, 0 if not)
CP = No. of conflicted point (CP/km)

## 2- DATA COLLECTION

To achieve the general purpose and objectives of this research, traffic accidents data provided from different sources were used mainly;

**i) Data from previous studies:** these data include previous research which was done in Egypt in different regions. List of Previous studies are given in Table (2).

1- El Behairy [9] 2- Abou-EL Naga [7]
3- Development research and Technological Planning Center (DRTPC) [15]
4-Amr wahballa [8]

Table (2) list of pervious studies of road accidents

| No. | Reference | Title | Date | Roads |
|---|---|---|---|---|
| 1 | Behairy [9] | Study on Road Accidents Analysis and Prevention | 1989 | 1- Cairo–Alex (agr)<br>2- Cairo–Alex (des)<br>3- Cairo–Fayoum(des)<br>4- Cairo–Suez(des)<br>5- Cairo–Ismailia (des)<br>6- Cairo– upper Egypt (agr) |
| 2 | Abou-EL Naga [7] | Accident Analysis on Main Roads Network of Dakahlia Governorate | 1998 | 1- Kafer EL-Arab- sherbien(agr)<br>2- Mansoura –sinbellawene(agr)<br>3- Mansoura- materiya (agr)<br>4- Mansoura –meet ghamer (agr)<br>5- Mansoura –sherbien (agr) |
| 3 | DRTPC [15] | "Safety and Protection of Public Transport on The Rural Roads in Egypt" for "The General Authority of Roads, Bridges, and Land Transport – Ministry of Transportation" | 2003 | 1- Cairo–Alex (agr)<br>2- Cairo–Alex (des)<br>3- Bani suaif - El Ayat(agr)<br>4-Ismailia - Port Said (des)<br>5- El Korayemat -El Zaafarana (des)<br>6- Cairo–Fayoum (des)<br>7- Assiut –Sohag (agr)<br>8- SHakshok –kota (agr)<br>9- Agha- EL mansora (agr) |
| 4 | Amr wahballa [8] | Analysis And Modeling of Traffic Accident on Upper Egypt Rural Roads | 2006 | 1- kom-Ombo-Edfu (agr)<br>2- Aswan-kom-Ombo (agr) |

**ii) <u>Data from Assiut rural roads network:</u>** traffic accidents data provided from assiut region included Accident data details for each accident from "General Authority for Roads & Bridges, Land Transport" (GARBLT) and data collected from field survey in assiut region. Selected roads are given in table (3.a). And in Table (3.b) explain the effort has been done in field surveying to collect the effective road characteristics, traffic operational conditions and, environmental conditions at the locations of the accidents repeated for Roads in Assiut network.

Table (3.a): Studied road selection in Assiut network

| ID | Road Name | Symbol | L | Road type |
|---|---|---|---|---|
| 1 | Assiut-sohag | ASS | 95 | Agriculture |
| 2 | Assiut- EL menia | ASM | 128 | Agriculture |
| 3 | EL menia- Bani suaif | MBS | 125 | Agriculture |
| 4 | Assiut - EL menia east desert | AMED | 125 | Desert |
| 5 | EL menia- Bani suaif east desert | MBED | 128 | Desert |
| 6 | Assiut - EL menia west desert | AMWD | 116 | Desert |
| 7 | EL menia- Bani suaif west desert | MBWD | 125 | Desert |

Table (3.b): Field survey form for Assiut region

| | | | |
|---|---|---|---|
| | Road name: | | Km: |
| | **Type of data** | **Describe** | |
| Cross Section Characteristics | 1) Road Type | 1- Agriculture Undivided | 2- Desert undivided |
| | 2) Total width of direction included paved Shoulder (m) (R/L) | | |
| | 3) Median Width (m) (M) | | |
| | 4) Surface Condition (SC) | ( 1-Good 2- Fair 3- Collapsed ) | |
| | 5) Horizontal Curved length: | | |
| Road side elements | 6) Shoulder Width (m) (R/L) | R | |
| | | L | |
| | 7) Traffic Signs status | 1-Good (clear) 2- Bad(not readied) 3- No Exist | |
| | 8) Land Marking | ( 1-Good 2- Bad 3- No Existence ) | |
| | 9) Lighting | 1-Good(two side) 2- Bad(one side) 3- No Exist | |
| Environmental characteristics | 10) Land Use | 1-Residential 2- Residential No Exist | |
| | 11)No. of conflicting points | | |
| | 12) Pedestrian Crossing | 1- no facilities (Random) 2- facilities(Bridges, Tunnels, Land Marking) 3- No Exist | |
| Traffic characteristics | 14)ADT | | |
| | 15) percentage of trucks | | |
| Note:- | | | |

## 3- RESEARCH METHODOLOGY

To develop a general model for accidents data available has been splittied into two groups according to its location as 1) Agriculture roads undivided sections 2) Desert roads undivided sections. Analysis was carried out by SPSS (V17) program to calibrate models for each type of road section.

Dependent variable considered was accident rate (AR) as Model (7). Independent variables were 12 variables as pavement width, shoulder width, ADT, percentage of trucks, traffic signs, lane marking, conflicting points, ….. etc.

Accident rate (AR) is the accident number divided by the vehicle exposure. It is expressed as accident per million vehicles-kilometers for road section per year **[**16**]** Exposure is defined as the count of the number of times vehicles are exposed or open to the paths of others.

$$\text{Accident rate (AR)} = \frac{\text{Number of accidents} * 1000{,}000}{\text{AADT x 365 x NY x L}} \quad \ldots\ldots\ldots\ldots\ldots(7)$$

Where: NY= number of years. L= section length

Simple Regression Analysis gives the correlation between average accident rates at all accident locations and each of the studied parameters using different mathematical forms; linear, logarithmic, power, Polynomial, and exponential regression models. To find the most significant relationship correlating the average accident rate and the considered parameter, models are suggested as a linear, logarithmic, power, Polynomial, and exponential simple regression models respectively.

Many of parameters contribute together to cause accidents, therefore simple regression analysis may give improper results Multiple Regression Models would be the proper one and the combined effect of these parameters on accident rates must be taken into consideration. Models (8, 9, 10 and 11**)** show the formulas of linear, logarithmic, power, and exponential multiple regression models respectively.

$$Y = B_0 + B_1 * X_1 + B_2 * X_2 + \cdots\cdots + B_i * X_i \quad \ldots\ldots (8)$$

$$Y = B_0 + B_1 * Ln X_1 + B_2 * Ln X_2 + \cdots\cdots + B_i * Ln X_i \quad \ldots\ldots (9)$$

$$Y = B_0 + X_1^{B_1} + X_2^{B_2} + \cdots\cdots + X_i^{B_i} \quad \ldots\ldots (10)$$

$$Y = e^{B_0 + B_1 * X_1 + B_2 * X_2 + \ldots\ldots + B_i * X_i} \quad \ldots\ldots (11)$$

Where:

Y is the average accident rate

$X_i$ are the studied parameters (pavement width, earth shoulder width, …etc)

$B_i$ are the coefficients to be estimated by the model.

Stepwise Regression Analysis is the method used in multiple regression analysis. It considers a few important parameters out of a large set of parameters to construct a multiple regression function by select the variables have high effects in accident rate.

To accept any model, it must confirm to statistics tests. Two ANOVA statistical tests are conducted using SPSS package. The purpose of these tests is to establish whether there are any significant differences in the data used for models' calibration for different types of roads and sections. This would assist in deciding whether it is appropriate to increase the data set by using the data of several roads in the calibration of the models or it is better to develop separate predictive models for each of the considered roads. The first statistical test is the analysis of variance F-test. Using this test, one can examine the null hypothesis that the available data represents a sample from populations in which the means of the test variables (i.e. ADT, SW,…) are similar in several independent groups. If a significant F-value (i.e. F_calculated > $F_{(df1,df2)(\alpha)}$ from statistic tables) would like to establish the group pairs that are significantly different and have good model, and if F-value is insignificant (i.e. F_ calculated < $F_{(df1,df2)(\alpha)}$ from statistics tables) would be advisable to develop separate predictive models for each of these roads individually. There is another statistical test; t-tests can be conducted for each pair of roads. This is similar to the F-test but restricted to a comparison of only two groups at a time. In this research, the least significant difference multiple t-tests are used to perform all pair wise comparisons of means of accident and traffic related variables between each possible pair of the considered roads. Where in some cases t-test is significant, i.e. there is no difference in population means of considered variables that may be a result of differences in roads (i.e. $|$t-test_calculated$|$ > $\text{t-test}_{(df1,\alpha)}$ from statistics tables).

# 4- ANALYSIS OF ACCIDENTS DATA

To investigate the highly affected factors which would lead to the occurrence of traffic accidents, all probable factors should be considered and analyzed. Roadway characteristics, traffic compositions, environmental conditions in addition to human factors must be considered.

The occurrence of accident results from complex integration among a driver, vehicle roadway, and environment. Accident data analysis shows that the most affected factor in accident occurrence is human factor, which involved in about 75 % of all accidents occurred on Egypt rural roads; vehicle, roadway, and environment were responsible of accident occurrence by the percentages of 17 %, 2 %, and 6 % respectively. Fig.(1, 2) Show the percentages of involving these factors in accidents occurrence to the total number of accidents occurred on Egypt rural roads according to traffic accident data report in Egypt (1999 to 2006).

**4.1 Human Factors**: Accident data analysis shows that the main factor of accident occurrence is the human factors which are responsible of about 75% of accidents. Human factors include drivers and pedestrians behavior. Accidents data analysis indicates that at grade crossing, pedestrians and animals increase accidents probability. About 8 % of all accidents occurred in sections have pedestrian and animal crossing. Where analyzed data shows that about 37% of all accidents occurred were due to over speeding. Also accidents data analysis shows that about 8 % of all accidents occurred in study area were wrong overtaking by driver which need an additional paved width and shoulder width space for overtaking. So, the behavior of the drivers in controlling speed and overtaking has high influence on reducing accident rate (AR).

**4.2 Vehicle Factors**: are the second highly affected factor in accident occurrence after human factors, which represent about 17 % of all accidents occurred on the selected roads. Vehicle types and tires condition have the main considerable factors in accidence occurrences. In this study analysis shows that trucks represent about 40 % of all vehicles involved in accidents occurred on the selected roads, about 48% of which are fatal accidents. This is due to the relatively large size and heavy loads of these vehicles which reduce the level of service on the road and restricts the freedom of drivers for maneuvering. Also tire burst has considerable factors in accidents .In the studied areas, about 14 % of all accidents occurred were due to worn-out tire.

**4.3 Roadway Factors**: Roadway factors have only about 2% in responsibility of accidents since roadway links included in the analysis were main rural links. Narrow roads, poor alignment, poor maintenance of pavement, objects beside road, non-functional signals and signs, patches, insufficient sight distance, and poor lighting were the most important deficiency of road characteristics causes accidents. The analysis indicated that the increasing in pavement width and earth shoulder width decreases accident rate**.** Wide pavement, and shoulder provides; a space for overtaking, allow moving vehicles to pass vehicles in the traffic lane and stopped vehicles, and recovery distance, which decrease roadside hazard.

**4.4 Environmental Factors**: Environmental conditions share about 6 % of all accidents occurred in Egypt. Weather condition and land surrounding the road may be residential, agricultural, industrial areas, desert, etc. Surrounding land affecting accident rates where it describing the existence of any entrances to the road and pedestrian or animal crosses it.

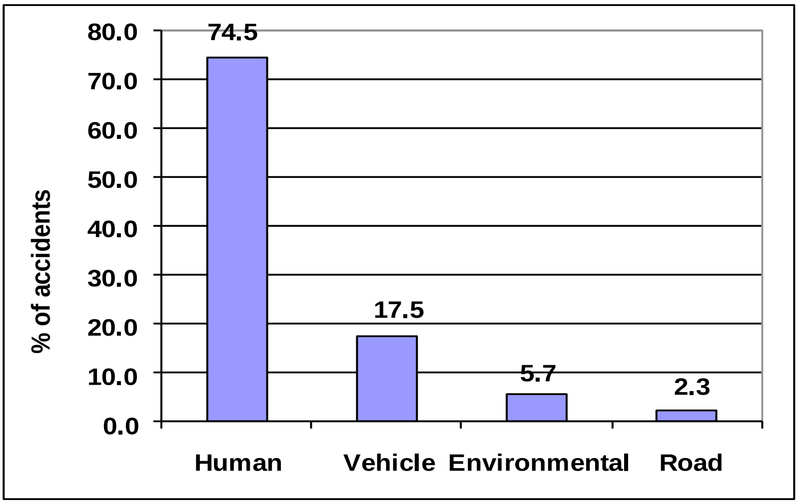


Fig. (1) Percentage of traffic accident causes factors on Egypt rural road

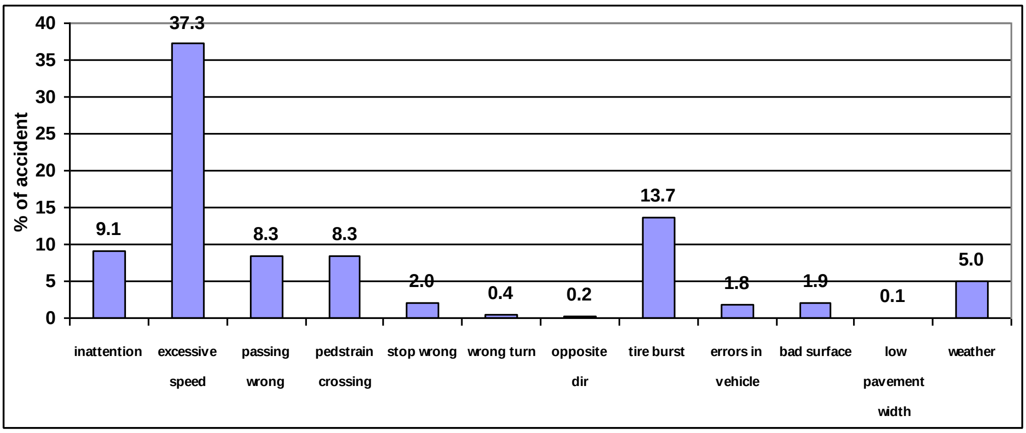


Fig. (2) Accidents causes on Egypt rural road according to traffic accident reported

## 5- ACCIDENTS MODELING

To identify traffic safety measures for Egyptian roads network, accident models must be done to evaluate accident probability causes. Also accident models help planners to develop roads network to be safer and reduce accidents rate, also accidents models help the decision makers to over come the accident causes.

To develop a general model of traffic accidents causes for Main Rural Roads in Egypt. The data available from previous studies and from data collected in Assiut region has been splittied into two groups according to its location as:

1) Agriculture roads undivided sections

2) Desert roads undivided sections

## a) Models For Agriculture Roads Undivided Sections

### i) Simple regression analysis

The correlation between average accident rates (AR) with each attribute variable was reached by simple regression analysis. Results are found in Table (4). From Table (4) it was found that the most models formula are exponential model in most variables, and for multi-regression analysis the exponential formula is the best one in most variables.

Table (4) Simple regression analysis models estimation for Agriculture Roads Undivided Sections

| ID | variables | N | Models type | $R^2$ | Model |
|---|---|---|---|---|---|
| 1 | ADT | 159 | Exponential | 0.591 | $AR= 2.483 *e^{-0.167 *(AADT/1000)}$ |
| 2 | SW | 159 | Exponential | 0.261 | $AR= 1.995 *e^{-0.628 *SW}$ |
| 3 | PC | 106 | Exponential | 0.180 | $AR= 0.547 *e^{0.319 *PC}$ |
| 4 | LUS | 158 | Exponential | 0.05 | $AR= 0.753 *e^{0.325 *LUS}$ |
| 5 | HDT | 159 | Exponential | 0.365 | $AR= 0.422 *e^{0.045 *HDT}$ |
| 6 | SC | 106 | Exponential | 0.153 | $AR= 0.550 *e^{0.336*SC}$ |
| 7 | p | 159 | Linear | 0.159 | AR= 4.573-0.323*P |
| 8 | LG | 106 | Quadratic | 0.356 | $AR= 0.624-0.855*LG+1.079*LG^2$ |
| 9 | MK | 106 | Exponential | 0.038 | $AR= 0.576 *e^{0.318*MK}$ |
| 10 | CL | 107 | Exponential | 0.034 | $AR= 0.846 *e^{-0.007*CL}$ |
| 11 | CP | 146 | Exponential | 0.029 | $AR= 1.081 *e^{-0.096 *CP}$ |
| 12 | TS | 106 | Exponential | 0.294 | $AR= 0.603 *e^{0.673*TS}$ |

Where:

N = Number of observations
AR = Accident Rate (accident /Million vehicle -Kilometer)
ADT = Average Daily Traffic (vehicle/day)*$10^{-3}$
CL = Percentage of horizontal curved length per Km
CP = Conflict point per Km
HDT = Percentage of trucks and heavy vehicles
LG = Lighting status (0 for two sides, 1 for one side, 2 for not exist)
LUS = Existing building area land use (1 if present, 0 if not)
MK = Marking status (0 for good, 1 for Bad (hidden), 2 for Not Exist)
P = Pavement width in meter
PC = Pedestrian crossing (0 for No crossing, 1 for Facility exists, 2 for random)
SW = Shoulder width for one side in meter
SC = Surface condition (good=0, fair =1, bad=2)
TS = Traffic signs status (0 for Good (readable), 1 for Bad (hidden), 2 for Not Exist)

### ii) Stepwise Multiple regression analysis method:

This technique helps in estimating the variables which have strong impact on traffic accidents. Table (5) shows stepwise regression analysis according to the coefficient of determination ($R^2$) and correlation matrix between variables, also statistical measure as F-test, t-test for these variables. In this technique ADT is taken as the main parameter that affects the accident rate and the other parameters are taken in step way manners. It was found that the coefficient of determination ($R^2$) increases significantly as variables added up to 7 steps where the increasing is nearly fixed. Therefore, 7 steps are chosen as the best step to estimate the parameters in model form, and F value is significant for this steps.

Table (5.a) Stepwise Regression Analysis for Agriculture Road Undivided Section Number of observations (N) are 159, degree of freedom ($df_1$) =159-7-1=151, degree of freedom ($df_2$) = 6

| ID | variable | $R^2$ | F-test |
|---|---|---|---|
| 1 | ADT | 0.591 | 226.4 |
| 2 | ADT+SW | 0.746 | 224.2 |
| 3 | ADT+SW+PC | 0.802 | 209.5 |
| 4 | ADT+SW+PC+LUS | 0.825 | 181.17 |
| 5 | ADT+SW+PC+LUS+HDT | 0.838 | 158.28 |
| 6 | ADT+SW+PC+LUS+HDT+SC | 0.850 | 143.45 |
| 7 | ADT+SW+PC+LUS+HDT+SC+P | 0.857 | 128.91 |
| 8 | ADT+SW+PC+LUS+HDT+SC+P+LG | 0.858 | 112.58 |
| 9 | ADT+SW+PC+LUS+HDT+SC+P+LG+MK | 0.858 | 99.45 |
| 10 | ADT+SW+PC+LUS+HDT+SC+P+LG+MK+CL | 0.858 | 89.36 |
| 11 | ADT+SW+PC+LUS+HDT+SC+P+LG+MK+CL+CP | 0.858 | 80.75 |
| 12 | ADT+SW+PC+LUS+HDT+SC+P+LG+MK+CL+CP+TS | 0.858 | 75.08 |

@$\alpha$ = 0.05, $df_1$=151, $df_2$=7, $f_{table}$=2.18 ($F_{cal}$=128.91 > $f_{table}$ then F is sig.)

Table (5.b) Correlations matrix Analysis and t-test Analysis for Agriculture Roads Undivided Sections

| Correlations matrix ($R^2$) | | | | | | | | | | | | | t-test | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| variable | Ln(AR) | ADT | SW | PC | LUS | HDT | SC | P | LG | MK | CL | CP | | |
| ADT | 0.591 | | | | | | | | | | | | -13.7 | Sig. |
| SW | 0.259 | 0.025 | | | | | | | | | | | -6.43 | Sig. |
| PC | 0.132 | 0.000 | 0.097 | | | | | | | | | | 5.80 | Sig. |
| LUS | 0.049 | 0.000 | 0.007 | 0.023 | | | | | | | | | 5.10 | Sig. |
| HDT | 0.365 | 0.103 | 0.016 | 0.098 | 0.005 | | | | | | | | 4.8 | Sig. |
| SC | 0.112 | 0.060 | 0.091 | 0.007 | 0.000 | 0.027 | | | | | | | 4.24 | Sig. |
| P | 0.134 | 0.007 | 0.155 | 0.182 | 0.000 | 0.102 | 0.073 | | | | | | -2.86 | Sig. |
| LG | 0.162 | 0.174 | 0.108 | 0.002 | 0.015 | 0.106 | 0.000 | 0.025 | | | | | 1.8 | Sig. |
| MK | 0.028 | 0.030 | 0.020 | 0.000 | 0.020 | 0.016 | 0.021 | 0.011 | 0.015 | | | | -1.1 | inSig. |
| CL | 0.026 | 0.024 | 0.021 | 0.000 | 0.004 | 0.004 | 0.003 | 0.004 | 0.129 | 0.002 | | | -0.92 | inSig. |
| CP | 0.028 | 0.026 | 0.000 | 0.018 | 0.002 | 0.010 | 0.005 | 0.036 | 0.015 | 0.000 | 0.018 | | 0.6 | inSig. |
| TS | 0.215 | 0.110 | 0.162 | 0.017 | 0.018 | 0.028 | 0.070 | 0.019 | 0.101 | 0.001 | 0.078 | 0.010 | -0.4 | inSig. |

@$\alpha$ = 0.05, $df_1$=151, t-$test_{table}$=1.66, (sig. if $|$t-$test_{cal.}|$ > t-$test_{table}$, insig. if $|$t-$test_{cal.}|$ > t-$test_{table}$)

Multiple regression analysis is developed in model (12).

$$Ln(AR) = 0.920-0.128*(ADT/1000)-0.301*SW+0.012*HDT+0.236*LUS+0.168*SC +0.12*PC-0.053*P$$

$R^2$=0.857, F=128.91 (Sig.) ……………………... (12)

## b) Models for Desert Roads Undivided Sections

### i) Simple regression analysis

The correlation between average accident rates (AR) with each attribute variable was reached by simple regression analysis. Results are found in Table (6). From Table (6) it was found that the most models formula are exponential model in most variables, and for multi regression analysis the exponential formula is the best one in most variables.

Table (6) simple regression analysis models estimation for Desert Roads Undivided Sections

| ID | variables | N | Models type | $R^2$ | model |
|---|---|---|---|---|---|
| 1 | SW | 74 | Exponential | 0.585 | $AR=1.505*e^{-0.488*(SW)}$ |
| 2 | CL | 74 | Exponential | 0.134 | $AR=0.793*e^{-0.008*CL}$ |
| 3 | SC | 70 | linear | 0.086 | AR=0.664+0.122*SC |
| 4 | HDT | 74 | Exponential | 0.282 | $AR=0.021*e^{0.098*HDT}$ |
| 5 | ADT | 74 | Exponential | 0.154 | $AR=2.255*e^{-0.243*(AADT/1000)}$ |
| 6 | p | 74 | Exponential | 0.383 | $AR=2.659*e^{-0.118*P}$ |
| 7 | CP | 74 | linear | 0.045 | AR=0.845-0.085*CP |
| 8 | MK | 70 | Exponential | 0.011 | $AR=0.689*e^{0.064*MK}$ |
| 9 | TS | 70 | Exponential | 0.198 | $AR=0.605*e^{0.206*TS}$ |
| 10 | LG | 70 | Exponential | 0.258 | $AR=0.480*e^{0.322*LG}$ |

### ii) Stepwise Multiple regression analysis method

In Table (7) shows the steps of stepwise regression analysis according to coefficient of determination ($R^2$) and correlation matrix between variables, also statistical measure as F-test, t-test for these variables. In this technique shoulder width (SW) is taken as the main parameter that affects the accident rate and the other parameters are taken in step way manners. It was found that the coefficient of determination ($R^2$) increases significantly as variables added up to 6 step. Therefore, 6 steps are chosen as the best one to estimate the parameters in model form (13). F value is significant for this step.

Table (7.a) Stepwise Regression Analysis for desert Roads undivided Sections
Number of observations (N) are 74, $df_1$=74-6-1=67, $df_2$= 6

| ID | variable | $R^2$ | F-test |
|---|---|---|---|
| 1 | SW | 0.585 | 95.99 |
| 2 | SW+ CL | 0.655 | 63.73 |
| 3 | SW+ CL+SC | 0.685 | 47.79 |
| 4 | SW+ CL+SC+ HDT | 0.707 | 39.18 |
| 5 | SW+ CL+SC+ HDT+ADT | 0.717 | 32.36 |
| 6 | SW+ CL+SC+ HDT+ADT + P | 0.726 | 27.78 |
| 7 | SW+ CL+SC+ HDT+ADT + P +CP | 0.726 | 23.53 |
| 8 | SW+ CL+SC+ HDT+ADT + P +CP + MK | 0.727 | 20.43 |
| 9 | SW+ CL+SC+ HDT+ADT + P +CP + MK +TS | 0.728 | 17.95 |
| 10 | SW+ CL+SC+ HDT+ADT + P +CP + MK +TS +LG | 0.729 | 15.91 |

@$\alpha$ = 0.05, $df_1$=67, $df_2$=6, $f_{table}$=2.25 ($F_{cal}$=27.78 > $f_{table}$ then F is sig.)

Table (7.b) Correlations matrix Analysis and t-test Analysis for desert Roads undivided Sections

| Correlations matrix ($R^2$) | | | | | | | | | | | t-test | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| variables | Ln(AR) | SW | CL | SC | HDT | ADT | P | CP | MK | TS | | |
| SW | 0.585 | | | | | | | | | | 4.32 | Sig. |
| CL | 0.134 | 0.018 | | | | | | | | | 3.61 | Sig. |
| SC | 0.070 | 0.021 | 0.002 | | | | | | | | 3.40 | Sig. |
| HDT | 0.282 | 0.105 | 0.045 | 0.025 | | | | | | | 2.8 | Sig. |
| ADT | 0.154 | 0.102 | 0.062 | 0.010 | 0.135 | | | | | | 2.2 | Sig. |
| P | 0.383 | 0.095 | 0.016 | 0.016 | 0.053 | 0.022 | | | | | 1.9 | Sig. |
| CP | 0.035 | 0.062 | 0.066 | 0.014 | 0.082 | 0.069 | 0.054 | | | | 1.2 | InSig. |
| MK | 0.011 | 0.003 | 0.118 | 0.011 | 0.003 | 0.181 | 0.024 | 0.062 | | | 0.82 | InSig. |
| TS | 0.188 | 0.237 | 0.114 | 0.031 | 0.052 | 0.006 | 0.212 | 0.018 | 0.005 | | 0.63 | InSig. |
| LG | 0.245 | 0.371 | 0.058 | 0.004 | 0.058 | 0.080 | 0.292 | 0.024 | 0.050 | 0.189 | 0.28 | InSig. |

@$\alpha = 0.05$, $df_1=67$, $t\text{-test}_{table}=1.67$, (sig. if $|t\text{-test}_{cal.}| > t\text{-test}_{table}$, insig. if $|t\text{-test}_{cal.}| > t\text{-test}_{table}$)

Multiple regression analysis is developed in model (13) where shoulder width (SW) has strong impact in this model.

Ln(AR) = - 0.702 - 0.261*SW+0.039*HDT-0.077*(ADT/1000)-0.033*P - 0.005*CL + 0.111*SC

$R^2$=0.726, F=27.78 (Sig.) …………………………..(13)

From all above steps it is suggested two models of traffic accident prediction for main rural road in Egypt, where ADT has strong effect on agriculture roads undivided sections and shoulder width (SW) have strong effect on desert roads undivided sections. Final general selected models in Egypt are shown in Table (8),

Table (8) Final selected models of traffic accidents prediction for Main Rural Roads in Egypt

| **Case** | **Model** | **$R^2$** |
|---|---|---|
| Agriculture roads undivided sections | Ln(AR)=0.920-0.128*(ADT/1000) -0.301*SW +0.12*PC +0.236*LUS +0.012*HDT +0.168* SC - 0.053* P | 0.857 |
| Desert roads undivided sections | Ln(AR)= -0.702-0.261*SW-0.005*CL+0.111*SC+ 0.039 *HDT -0.077*(ADT/1000)- 0.033*P | 0.726 |

## 6- CONCLUSIONS

1. Human factors are responsible of nearly 75% of all accidents occurrence on main Rural Roads in Egypt the selected roads while vehicles, roadway characteristics, and environmental factors were responsible as nearly 17 %, 2 %, and 6 % respectively.

2. Speed limit violation represents about 37 % of all accidents occurred (Human factors), and Tire burst is the main cause of accidents in about 14 % of all accidents occurred, (Vehicles factors).
3. Multiple regression analysis showed that exponential models represent the highest correlation between accident rate and factors affecting it.
4. Results of regression analysis show that shoulder width has high effect on traffic accident. A reduction in accident rates of about 45%, 41%, is attained when shoulder width is increase from 1 to 3 m for paved width ≤ 8 m for agriculture roads undivided sections, desert roads undivided sections respectively, (Roadway characteristics).
5. Analysis shows that trucks represent about 40 % of all vehicles involved in accidents occurrence, and 48% of which are fatal accidents. Models show that increasing Percentage of trucks in the traffic volume increases accident rate. It is recommended that heavy trucks should be separated and shifted to special lanes.
6. Land uses as building on any side of the road, presents conflict points at its location of the road. And random pedestrian crossing or animal crossing, represent more dangerous location at any section of roads, where about 8% of all accident occurred.

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## " تحليل ونمذجة أسباب حوادث المرور علي الطرق الخلوية الرئيسية في مصر"

يهدف هذا البحث إلى نمذجة وتحيل تكرار الحوادث علي الطرق الرئيسية الخلوية في مصر على مختلف أنواع الطرق الغير مقسمة وكذلك تبعاً لموقعها صحراوية أم زراعية و محاولة التوصل إلي نموذج عام ليربط بين الحوادث و مسبباتها وكذلك الوقوف علي المسببات الرئيسة للحوادث.

اعتمد هذا البحث في تحليل ونمذجة البيانات علي بيانات مفصلة من أبحاث سابقة علي ( 19 وصلة طريق) وبيانات حقلية تم تجميعها علي ( 7 وصلات طريق) تابعة للهيئة العامة للطرق والكباري بأسيوط والتي يمكن أن تمثل جغرافياً جميع أنواع الطرق في مصر وهذه البيانات قسمت إلي قسمين" طرق زراعية غير مقسمة" و"طرق صحراوية غير مقسمة".

تم دراسة وربط معدلات الحوادث Accident Rate (AR) مع 12 مسبب، لهم تأثير على حوادث الطرق ودرس كل مسبب علي حدة ثم مع العوامل مجتمعة واستنتاج العلاقات التبادلية ومدى الارتباط باستخدام التحليل البسيط Simple Regression Analysis والتحليل المتعدد الحدودMultiple Regression Analysis .باستخدام طريقة Stepwise.

يمكن الاستفادة من نتائج هذا البحث في تقييم مستوى الأمان على الطرق وفى دراسة تأثير تحسين عوامل الأمان على تكرار الحوادث وعلى إمكانية وضع أولويات لتحسين هذه العوامل لرفع مستوى الأمان على الطرق.

العامل البشري شارك في حوالي 75 % من إجمالي الحوادث بينما يشارك عوامل المركبات و الطريق و البيئة بنسب حوالي 17 % و 2 % و 6% من إجمالي الحوادث علي التوالي وهذا يؤكد الضرورة إلي الوقوف علي العوامل والأسباب وانتهاج السبل التي تؤدي للارتقاء بالعامل البشري وذلك حتى يمكن خفض معدلات الحوادث علي الطرق في مصر.

في حالة قطاعات الطرق المختلفة وجد أن عرض الطبان له تأثير مهم علي الحوادث حيث كلما زاد عرض الطبان قل معدل الحوادث, وأيضا نسبة النقل لها تأثير علي الحوادث حيث أنها تمثل حوالي 40% من نسبة المركبات المشتركة في الحوادث ويوصي البحث بإيجاد مسارات خاصة للنقل الثقيل.