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An Alternative Approach for Predicting the Accident Involvement Probability for Drivers in Peshawar City, Pakistan

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Abstract- **Road traffic accidents are a primary global concern, considering its magnitude and gravity, and the subsequent negative impacts on the economy and general well-being of the public. Pakistan is no exception to this worldwide dilemma, with the highest incidence of road traffic accidents in recent years. Large cities like Peshawar are rapidly transforming into cities of congestion as they face severe road safety problems. Past Studies have revealed that of the many factors affecting road traffic accidents in Pakistan, the factor of driver is the deadliest, which is why this study aims to understand and model the effect of different driver characteristics on road traffic accidents in Peshawar city of Pakistan. The database for this study is constituted via survey questionnaire and based on the continuous nature of the dependent variable; multiple linear regression analysis is used in this study. The results show the best three models based on the R square and sum square error, are the models 8, 12 and 16, with R square values of 0.81, 0.91, 0.91 and SSE values of 0.460, 0.469 and 0.586, respectively. This study thus provides an alternative approach to estimate the probability of a driver's involvement in road traffic accidents and eliminates the need for other costly and time-consuming studies like psycho technical research.**

***Index Terms*--**: **Accident Prevention, Multiple Regression Analysis, Road Traffic Accidents, Road Safety**

I. INTRODUCTION

Road Safety is a major public health and development concern around the world. According to the World Health Organization [1] Road Traffic Accident (RTA)is the 8th most leading cause of death around the world; it is estimated that about 1.35 million people die on the world's roads annually, whereas an additional 20 to 50 million people are left with non-fatal injuries, with many acquiring a handicap. Over 90% of the fatal crashes are recorded in the low and middle income countries (LMICs), imposing a huge socio-economic cost in terms of untimely deaths, injuries, and loss of potential income, as WHO estimated that about 3 to 5 percent of their GDPs are lost to RTAs every year [2].

A. ROAD SAFETY SITUATION IN PAKISTAN

Road safety in Pakistan has been really poor, despite the fact that road transportation accounts for over 6% of the country's employment and contributes nearly 10% to the GDP [3]. Every year on an average about 7000 road users are killed in RTAs [4]. Since 2015, numbers of reported RTAs have continuously been ascending [5]. However, these numbers significantly under estimate the severity of the situation as many non-fatal RTAs are not reported to the police [6]. With challenges of rapid population growth, urbanization and resultant motorization the road safety situation is deteriorating day by day. The number of registered vehicles is projected to rise from 18 million in 2018 to 65 million by 2030 [7]. One can easily foresee that with such an alarming rate of motorization and an annual population growth rate of 2% along with annual urbanization rate of 3% [8], a rise in the numbers of RTAs and fatalities is inevitable in the coming years.

B. ROAD SAFETY SITUATION IN PESHAWAR

Peshawar, being the capital city of Khyber Pakhtunkhwa (KPK) is the major political, educational and economic epicenter of the province. It is one of the ten largest cities of the country with a projected population of 3.57 million and a registered vehicular population of 521,150, that is growing at an average annual rate of 12.83% [3]. With an increasing vehicular population, Peshawar city is facing serious road safety and traffic management problems [9]. Since 2016, Peshawar city has reported the highest number of RTAs in KPK [10] and which is why it can be considered as well suited for this study.

C. MAJOR CRASH CAUSING FACTOR

Many studies have previously identified different factors that are involved in the occurrence of RTAs. Khan & Tehreem [11] found

that most of the RTAs are caused by a lack of awareness among drivers, over speeding, use of mobile phones and by other driver and vehicle-related factors. Adnan et al [12] concluded that about 80 percent of the accidents on motorways are caused by careless driving, brake failure, dozing on the wheel and tire bursts. Batool et al [13] found that 80 percent of the fatal crashes involved licensed drivers and attributed that to their insufficient knowledge about traffic signs, rules and regulations. Similarly, Hussain et al [14] found that negligence of traffic laws causes about 87 percent of the motor-vehicle crashes in Pakistan.

D. DRIVER CHARACTERISTICS

While there are many driver characteristics that can influence a driver's behavior and his involvement in RTAs, this study handles only five driver characteristics.

a) GENDER

Many studies have reinforced the conviction of contrasting driving characteristics for both genders and found that generally, male drivers have a higher accident ratio compared to female drivers [15]. Anderson et al [16] concluded that the differences in driving behaviors and attitudes are primarily a function of driver's age and gender. Similarly, Clarke et al [17] found that there is a higher tendency of aggressive driving among male drivers and hence they are more likely to be involved in RTAs compared to young female drivers.

Gender effects on RTAs are not only evident in frequency but also in accident consequences, as comparatively a higher ratio of male drivers are involved in fatal crashes [15].

b) AGE

The correlation between age and accident involvement probability has most frequently been investigated in the literature. In general, younger drivers have a higher accident ratio till the age of 25, though it decreases with age, the ratio shoots up once again for elderly drivers after the age of 60 [18]. Similarly, Clarke et al [17] concluded that young male drivers aged 17-19 years are more likely to be involved in accidents compared to drivers aged 20-25 years.

These findings can be attributed to the overconfidence shown by young drivers in their driving abilities, a higher tendency of aggressive driving behavior and over speeding. Whereas, for elderly drivers it can be associated with age-related decline in agility, visual functioning and other cognitive abilities [19].

c) LEVEL OF EDUCATION

Education plays a vital role in molding the attitudes and behaviors of drivers. Sami et al [20] found that the driver's level of education directly affects RTAs and accident mortality rate. Education can ensure that road users i.e. drivers, passengers and pedestrians behave responsibly on the roads, as an educated driver behaves and responds more logically while driving, compared to an uneducated driver [18].

d) DRIVING EXPERIENCE

Driving experience has been recognized as a significant risk factor, especially for the safety of novice and young drivers. Generally, drivers with low experience have a higher accident ratio than experienced drivers. Experience enables drivers to read and assess the driving environment in a much better manner. Moafian et al [21] found that the accident involvement percentage decreased from 15.90 percent for novice drivers with a fresh license to 3.13 percent after ten years of driving experience. According to Alfonsi [22] the reduction in accident ratio for experienced drivers can be attributed to the fact that driving experience plays a big part in the evolution of several cognitive and behavioral skills such as information processing, hazard recognition, attention allocation and vehicle maneuvering.

e) AVG KMS DRIVEN PER DAY

The magnitude and frequency of driving have a strong relationship with accident involvement. Generally, the longer one drives, the higher is the possibility of him getting involved in an accident, as his driving performance deteriorates with continuous-time in driving. According to Lyznicki et al [23] continuous-time in driving results in fatigue which causes a reduction in alertness by increasing the reaction time and decreasing the information processing efficiency of the driver.

II. METHODOLOGY

A. DATA COLLECTION

For this study, Peshawar, the capital city of KPK province, was selected as the study area based on its population density and high incidence of RTAs compared to other districts in the province.

A Questionnaire was designed and randomly applied to 2,662 drivers in the city on a face-to-face basis. The following equation was used to calculate the minimum number of drivers that had to be interviewed for the sample to reflect the target population as precisely as desired [24]:

$$\text{Sample Size (SS)} = \frac{Z^2 . p . (1-p)}{MOE^2} \quad (1)$$

Where: Z = Z value i.e., 1.95 for 95% confidence level
p = sample proportion, 0.50 gives the largest sample size
MOE = Margin of Error, 2%=0.02

SS = 2,377 (Minimum Sample Required from this Study)

B. MULTIPLE LINEAR REGRESSION

The multiple linear regression is well suited for explaining the relationship between one continuous dependent variable and two or more independent variables. The dependent variable in this study being a continuous variable was modeled using the multiple regression analysis. The following equation gives the relationships between the dependent and independent variables [25-31]:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots + \beta_k X_k + e \quad (2)$$

Where Y is the dependent variable, X_1-X_k are the independent variables, β_1-β_k represents the coefficients of the respective variables while β_0 represents the Y intercept (constant). The variables are defined in Table I.

TABLE I
VARIABLE DESCRIPTION AND SPECIFICATION

variables	Notation	Description
GENDER	x_1	1= Male, 2=Female
AGE	x_2	1, if $x_2<26$ 2, if $25<x_2<36$ 3, if $35< x_2<46$ 4, if $45< x_2<56$ 5, if $x_2>55$
LEVEL OF EDUCATION	x_3	1=Illiterate 2=Primary/Middle 3=Matric 4=Intermediate 5=Graduate
DRIVING EXPERIENCE	x_4	1, if $x_4<1$ 2, if $1<x_4<6$ 3, if $5< x_4<11$ 4, if $10<x_4<20$ 5, if $x_4>20$
AVERAGE KMS DRIVEN PER DAY	x_5	1, if $x_5<51$ 2, if $50<x_5<151$ 3, if $150< x_5<251$ 4, if $250< x_5<351$ 5, if $x_5>350$
ACCIDENT INVOLVEMENT PROBABILITY	Y	Number of drivers involved in RTAs (N_i) / number of drivers in the subgroup (N_t)

C. SUB-GROUPING

To model the constituted database, the database was coded using the description given in Table 1. Based on the driver characteristics, the coded data were further classified into subgroups. All possible combinations of 3, 4 and 5 variables were used for sub-grouping in this study. For example, a female driver assigned–as subgroup no; Gender: 2, of age under 35 years old –as Age: 3, having a university degree –as Education: 5, of 6 years driving experience –as Experience: 3 and with an average mileage of less than 50 kilometers per day–as kms/day: 1 belongs to a distinct subgroup coded as 23531.

D. ACCIDENT INVOLVEMENT PROBABILITY

The dependent variable Y i.e., the accident involvement probability for a subgroup, was defined as the number of drivers involved in RTAs divided by the total number of drivers in that subgroup. For example, a subgroup having 20 drivers wherein 5 are involved in RTAs; the output in terms of accident probability is 25 percent.

E. EVALUATION CRITERIA

The performance of the models was evaluated using a tried and tested method i.e. comparison of R^2 and the Sum squared error (SSE) values [18, 26]. The models with the higher values of R^2 and the lower values of SSE best represented the database in this study.

III. RESULTS & DISCUSSION

A. DESCRIPTIVE STATISTICS ANALYSIS

The results of descriptive statistics analysis are summarized in Table II. Out of the 2662 drivers interviewed in Peshawar, 563 drivers were involved in RTAs. Majority of the respondents were male drivers (91.5%). Of the 563 drivers inovled in RTAs over 90% were male drivers and only 9.6% were female drivers. Age wise young drivers aged less than 26, had a greater accident ratio (36.9%) than other age groups. As for education level, over 80% of the drivers involved in RTAs were educated drivers, majority of whom were university graduates (41.2%). Experience wise, almost 70% of the drivers involved in RTAs had less than 11 years of driving experience. Whereas, in terms of average kms driven per day, majority (59%) of the drivers drove less than 150 kms per day.

TABLE II
DESCRIPTIVE STATISTICS ANALYSIS

Variables	Percent	Percent of total drivers involved in RTAs
GENDER		
Male	91.5	90.4
Female	8.5	9.6
AGE (years)		
<25	31.0	36.9
25-35	30.2	30
36-45	25.4	23.3
46-55	8.7	6.7
>55	4.7	3
LEVEL OF EDUCATION		
Illiterate	18.7	14.2
Primary/Middle	13.4	13
Matric	18.1	16.2
Intermediate	13.4	15.5
Graduate	36.3	41.2
DRIVING EXPERIENCE (Years)		
<1	12.4	14.9
1-5	24.4	27.7
6-10	25.2	25.4
11-20	22.2	20.8
>20	15.9	11.2
AVG KMS DRIVEN PER DAY		
<50	29.3	26.1
50-150	32.7	32.9
150-250	25.7	27.4
250-350	8.5	9.4
>350	3.8	4.3

a) MULTIPLE REGRESSION ANALYSIS

A multiple regression analysis was run to predict the accident involvement probability based on the driver characteristics defined in Table I. The results of the regression analysis are summarized in Table III. It shows that a total of 16 models have

been developed using the subgroup numbers and the number of drivers in the subgroup (Nt) as independent variables.
Moreover, the application of the performance evaluation criteria in Table III indicates that model 8, 12 and 16 predicts the dependent variable comparatively well by explaining a greater percentage of the total variation in the dependent variable in terms of R squared and SSE.

TABLE III
MULTIPLE REGRESSION ANALYSIS SUMMARY

Model No.	Independent Variables	Number of Subgroups	R^2	Sum of Squared Error (SSE)
1	x_1, x_2, x_3, Nt	29	0.58	0.728
2	x_2, x_3,x_4, Nt	57	0.53	1.539
3	x_1, x_2, x_4, Nt	24	0.66	0.622
4	x_2,x_4,x_5, Nt	51	0.72	0.554
5	x_3,x_4,x_5, Nt	67	0.75	0.613
6	x_1,x_3,x_4, Nt	31	0.53	1.116
7	x_1,x_4,x_5, Nt	28	0.73	0.349
8	x_2,x_3,x_5, Nt	58	0.81	0.460
9	x_1,x_3,x_5, Nt	28	0.61	0.526
10	x_1,x_2,x_5, Nt	27	0.58	0.974
11	x_1,x_2,x_3,x_4, Nt	65	0.5	1.578
12	x_2,x_3,x_4,x_5, Nt	107	0.91	0.469
13	x_1,x_2,x_4,x_5, Nt	106	0.61	1.464
14	x_1,x_2,x_3,x_5, Nt	66	0.82	0.506
15	x_1,x_3,x_4,x_5, Nt	76	0.73	0.727
16	x_1,x_2,x_3,x_4,x_5, Nt	116	0.92	0.586

The results of the selected models along with their coefficient of correlations are given in coefficients table IV, V and VI respectively. These coefficients tables reveal that for all models the independent variables invovled except Nt with $p<0.05$, statistically significantly predicted the accident involvement probability.

TABLE IV
REGRESSION COFFIENCENTS OF MODEL# 8

Variables	Coefficients (β)	t- stat	p-value
Intercept	0.317	5.973	<0.001
Age	-0.118	-9.619	<0.001
Education	0.067	7.285	<0.001
Avg kms driven per day	0.153	12.740	<0.001
Number of drivers	0.00061	1.355	>0.05

TABLE V
REGRESSION COFFIENCENTS OF MODEL# 12

Variables	Coefficients (β)	t -stat	p-value
Intercept	0.288	8.487	<0.001
Age	-0.100	-12.178	<0.001
Education	0.079	16.928	<0.001
Experience	-0.073	-9.464	<0.001
Avg kms per driven day	0.182	24.460	<0.001
Number of drivers	0.001	1.573	>0.05

TABLE VI
REGRESSION COFFIENCENTS OF MODEL# 16

Variables	Coefficients (β)	t-Stat	p-value
Intercept	0.287	5.703	<0.001
Gender	-0.027	-2.121	<0.05
Age	-0.112	-13.013	<0.001
Education	0.076	15.464	<0.001
Experience	-0.069	-8.735	<0.001
Avg kms driven per day	0.188	24.020	<0.001
Number of drivers	0.002	2.919	>0.05

Furthermore, the values under the “Coefficients" columns in table IV, V and VI gives the following regression equations respectively:

Model#8

$$Y = 0.317 - 0.118x_2 + 0.067x_3 + 0.153x_5 + 0.00061Nt \quad (2)$$

Model#12

$$Y = 0.288 - 0.100x_2 + 0.079x_3 - 0.073x_4 + 0.182x_5 + 0.001Nt \quad (3)$$

Model#16

$$Y = 0.287 - 0.027x_1 - 0.112x_2 + 0.076x_3 - 0.069x_4 + 0.188x_5 + 0.002Nt \quad (4)$$

Moreover, the F-ratios in table VII shows that the overall regression model is a good fit for the data. It reveals that the independent variables statistically significantly predict the dependent variable, with F (4,53) F (5,100) and F (6,109), significance $p<0.005$ for Model 8,12 and 16 respectively.

TABLE VII
ANOVA RESULTS

ANOVA MODEL# 8	df[a]	SS[b]	MS[c]	F ratio	p value
Regression	4	2.089	0.522	60.119	<0.005
Residual	53	0.460	0.008		
Total	57	2.549			
ANOVA MODEL# 12					
Regression	5	5.117	1.023	218.046	<0.005
Residual	100	0.469	0.004		
Total	105	5.587			
ANOVA MODEL# 16					
Regression	6	5.767	0.961	178.617	<0.005
Residual	109	0.586	0.005		

Total		115	6.353

[a] Degrees of freedom, [b] Sum Square, [c] Mean Square

IV. CONCLUSIONS

The study modeled the effects of driver characteristics on RTAs in Peshawar city, Pakistan. Based on to the results obtained from the descriptive statistics analysis and the multiple regression analysis, the following conclusions can be drawn:

a) Male drivers have a higher accident involvement probability compared to female drivers and hence are more liley to be invovled in RTAs.
b) Young male drivers below the age of 25 years have the highest probability of road accidents among all age groups.
c) The accident involment probability steadily drops for elderly and experienced drivers.
d) The general trend i.e. that drivers with higher education are less prone to RTAs is not true for Peshawar city as a higher percentage of graduate drivers are involved in RTAs.
e) Drivers with continous time in driving or high average kms driven per day are more likely to get inovled in RTAs.
f) Multiple regression analysis is an effective technique to model the effect of driver characteristics on RTAs. With the models built in this study accurate predictions can be made for the drivers that are not included in the database.
g) This study provides an alternative approach to estimate the risk of a driver's involvement in RTAs on the basis of their characteristics and eliminates the need of costly time consuming studies like psycho technical research.

V. RECOMMENDATIONS

This study can be useful in classifying drivers into different risk groups based on their characteristics. A risk-based training program can be introduced in the system while obtaining a new license or some controls can be performed later during the driving period at specific intervals. In other words, the risk of a driver's involvement in RTAs can be predetermined, before it becomes a reality in traffic. The drivers can be trained accordingly via a risk-based training program. Such a practice can prove to be much more effective in ensuring proper driving skills among the licensees and can be very helpful to the concerned authorities.

Moreover, similar studies can be carried out to model the effects of driver characteristics on RTAs in other cities of Pakistan. Similarly, effects of other factors like that of the vehicle, roadway, and the climatic environment can be modeled using more advanced modeling techniques i.e. neural network modeling.

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