ACCIDENT PREDICTION MODEL FOR PASSENGER CARS

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ABSTRACT

Presently about 40% of the vehicles plying on the roads of Lahore consist of passenger cars. The quantity of passenger cars is on rise with of time. This huge quantity of passenger cars necessitates the need to study the mechanical state of cars and behaviour of car drivers towards safety. For this purpose a questionnaire comprising more than 100 vehicular and drivers characteristics of passenger cars was prepared to conduct a field survey at 100 locations of a sample of 3,800 passenger cars. Statistical analyses using SPSS software was done to identify the most significant vehicular and drivers characteristics contributing to annual number of accidents by each car driver. An attempt is also made to develop an accident prediction model (APM) using linear multiple regression technique to estimate the annual number of accidents per car driver relating to the most significant vehicular and driver's characteristics of the passenger cars.

Keywords: passenger cars, accidents, Lahore, vehicular characteristics, driver's characteristics, accident prediction model.

INTRODUCTION

Lahore is the provincial headquarter of Punjab and the second largest populated city of Pakistan. As per Motor Vehicle Registration Authority, in 2004-05 the total registered vehicles in Lahore were 978,000. The number of passenger cars was 400,000, i.e. 40 % of the vehicles plying on the roads of Lahore. The number of passenger cars in Lahore has been increasing due to leasing schemes offered by banks and migration trend of people to Lahore from other parts of Punjab province. The passenger cars, being the 40% of the motorized vehicles in Lahore, have more contribution towards accidents in Lahore.

The accident data of Lahore was available from Police Headquarter (Years 2005-2008) and Rescue 1122 (Year 2007-2008) but this data only provides the general information about the number of accidents occurred by different vehicles in different zones of Lahore. The information about the location, time, types of accident (for example head on collision etc.), vehicles involved in the accidents, extent of vehicular damage, loss of lives, and etc., is not available in both types of accident data.

Most of the accidents result from a combination of several contributing factors, for example, characteristics of vehicle, behavior of drivers, violations by pedestrians, roadway elements, bad weather, etc. [(Hashmi et al. 2009), (Hashmi et al. 2010), (Pignatro, 1973) , (Qayyum, 1998), (Qayyum, 1999), (Qayyum, 2002), (Qayyum et al. 2007), (SARTRE, 1994)]. Accordingly after going through a lot of relevant literature and available accident data, a survey form including 112 questions was designed to study vehicular and driver's characteristics of passenger car with respect to their

accident potential in Lahore city. While designing the questionnaire it was kept in mind that the drivers could properly answer the questions in 30 to 45 minutes.

Accident Prediction Models (*APMs*) are mathematical equations used for prediction of the expected number of accidents on intersections and road sections. Lord et al. (2000) worked on the model for accident prediction at intersections. Kim et al. (2005) worked on an accident prediction model at four legged signalized intersections in Seoul City. Uçar et al. (2007) developed a model for bus accidents in Turkey relating effects of specific locations of accidents, accident time, weather conditions, direction of vehicle movement and educational level of the driver with the severity of vehicle damage. These models are for specific locations/intersections only and are not taking into account the vehicular and driver's characteristics exclusively. Hashmi et al. (2010) proposed two accident prediction models relating to number of accidents occurred per year based on the most significant vehicular and driver's characteristics of motorcycle rickshaws and wagons in Lahore.

To ensure the avoidance of traffic accidents occurring due to movement of passenger cars on the roads of Lahore, a detailed study was needed as no such study had been conducted in the past. Mostly accidents result from a combined effect of several contributing factors, for example, characteristics of vehicle and drivers, violations by pedestrians, roadway elements, bad weather, etc. (Qayyum, 2002). The basic objective of this study was the statistically determination of impact of the significant vehicular and driver's characteristics of passenger cars on the number of accidents occurred during last two years by the drivers, and hence to develop the Accident Prediction Model (*APM*) in line with Hashmi et al. (2010) models.

METHODOLOGY

Survey forms/ questionnaires to collect the data regarding the characteristics of vehicles and drivers of passenger cars were prepared and 100 survey sites were finalized in such a way that a representative data could be achieved. A survey team, consisting of students of University of Engineering and Technology, Lahore, was established to survey different sites within Metropolitan Lahore to collect the data regarding characteristics of vehicles and drivers. A sample of 3,800 was taken for the study, 1% of the total number of registered passenger cars in Lahore. After completing the data a coding manual was devised so that the collected information can be converted to the digits to form data base for the analysis. Statistical analyses of the collected data were carried out using software Statistical Package for Social Sciences (*SPSS*).

The questionnaire contains 112 variables. All of the variables do not significantly contribute to the accidents. In order to select most significant variables related to vehicular and driver's characteristics, the following procedure was adopted using *SPSS* software:

- Frequency analyses of all the variables showing their relation with number of accidents in last two years
- Cross-tabulation analyses between number of accidents in last two years and all variables
- Correlation analyses of number of accidents in last two years with all variables
- Establishment of different /significant groups of independent variables on the basis of preceding steps
- Final selections of the seven most significant variables taking into account their contribution towards accidents on the basis of their reliability
- Linear regression analyses using the most significant selected variables.

FREQUENCY ANALYSIS AND DISCUSSION

Based on the analysis using *SPSS*, the results regarding frequency analysis of vehicular and driver's characteristics of cars along with observations and discussion are given below:

- The most of the cars are being used for private purposes. Less than 1% cars are used as public transport.
- More than 50% of the cars are manufactured by M/s Pak Suzuki. It shows that most of the people are financially weak.
- Most of the cars are new as about 70% of the cars have make year as 2001 and onwards. The larger quantity of new cars indicates the strong financial condition of the masses but in actual the masses are financially weak. The reason for more new cars is that most of the car owners have acquired their vehicles from bank leasing facilities.
- Most of the cars have engine capacity of 800 cc. This aspect shows that most of the drivers are not financially strong.
- More than 90% of the cars have their speedometers, odometers, temperature and fuel gauges in working order. This is due to the fact that the cars are comparatively new.
- About 3% of the cars have loose foot brakes and 2% have hand brakes out of order. This small proportion is again due to the fact that the cars are not very old.
- About 2% of the cars have fire extinguisher available and 3% have reflecting triangles.
- Only 2% of the car drivers use safety belts while driving. The proportion of drivers violating safety precaution is huge. This aspect needs to be properly addressed by traffic police.
- About 2% of the drivers do not have spare tyres and tools for changing tyres. This aspect shows carelessness on driver's attitude.
- 1% of the cars have their horns, 3% have wind shield washers and 2% have wind shield wipers in non-working condition. These aspects indicate careless driving behaviour.
- More than 30% of the cars have power steering and about 3% have excessive play in the steering wheel. The excessive play in steering may cause serious accidents.
- In about 5% cars, left side or right side back view mirrors are not available. The unavailability of back view mirrors may lead to serious accidents.
- About 15% cars have front parking light, 3% have rear parking lights, about 2% of the cars have low or high beam, 2% of the cars have front or rear indicators and about 1% of the cars have brake lights and reverse gear lights in non-working condition. These factors indicate that drivers do not give due consideration to maintenance of electrical work.
- About 3% of the cars have tyres with excessive wear. The excessive wear may cause accidents especially in the rainy seasons.
- In case of 12% of the cars there do not exist number plates and 3% of the cars have improper quality of number plates. This shows carelessness on driver's part.
- About 6% of the cars have noisy exhaust sound system. Such cars drivers must be fined as they are responsible for creating noise pollution.
- About 20% of the cars have scratches on glasses, 10% have scratches on wind screen and at least 9% of the cars have any sign of damage on different parts of the cars. This shows that about 9% vehicles came across some road incident.
- More than 95% of the cars have radio, cassette players or stereo deck installed. The attention of traffic police is required in this aspect.
- More than 65% of vehicles have air conditioners and more than 75% of the cars have air heater.
- 95% of the drivers are male and 5% are female.

- More than 99% of the drivers are Pakistani nationals and less than 1% are foreigners.
- Age range of drivers is as under:

< 18 years	0.2 %
18 – 25 years	15.2 %
25 – 30 years	45.3 %
30 – 40 years	32.8 %
> 40 years	6.5 %

   The law enforcing agencies are required to ensure that the young people less than 18 should not be allowed to drive the cars.

- The drivers of the cars possess different qualification levels. 50% of drivers are graduates.15% have post-graduate level of qualification. The rest have qualification level of Intermediate or below.
- 40% of the drivers have driving experience of less than 10 years. 42% have 10-20 years and 15% have more than 20 years. Most of the drivers have 16,000- 20,000 km/year run of their cars.
- All the drivers admit that they have met accidents in their driving life and more than 95% admit that they came across such incidents during the last two years. This aspect needs to be properly addressed as almost all the drivers have the tendency of committing accidents.
- 44% the drivers are single and 56% are married. 48% have two kids. About 10% have 4 or more children. Less than 1% drivers are physically unfit.
- 25% the drivers smoke and 90% of them have been smoking for the last 5 to 15 years. 81% of smokers smoke 16 to 20 cigarettes per day. The campaigns should be initiated to inform the masses about the danger of smoking.
- 50% of the drivers have income range of Rs. 10,000-Rs. 15,000/- per month. This shows that the drivers are not financially strong.
- 3% drivers do not have driving license and 6% are unable to produce at the time of survey. The traffic police are required to address this aspect.
- 90% of the drivers claim that they take their cars for periodic fitness check-up and their frequency is once a month.
- Majority of car drivers use CNG as fuel as it is evident from the following:

Petrol	20.3 %
Diesel	12.1 %
CNG	67.6 %

- 4% the vehicles have signs of severe accidents intensity. 70% of the accidents occurred during evening or night. 8% of the drivers claim that they exceed speed limit. The traffic police should ensure observance of the speed limit.
- 36% of the drivers have complained regarding bad behaviour of police. 99% claim that they pay Rs. 200 per month to police.
- More than 40% of the drivers are not satisfied with their profession. This dissatisfaction may be one of the causes of road accidents.
- 3% of the cars have excessive exhaust smoke. More than 60% drivers have some type of insurance.
- 15% of the car drivers admit that they rarely or not strictly follow traffic rules. More than 85% drivers have been fined to any offence in driving exposure. The traffic police are required to ensure the observance of traffic rules.

CROSS-TABULATION ANALYSIS AND DISCUSSION

The cross tabulation analyses using *SPSS* software were carried out on all the parameters with special emphasis on the number of accidents occurred during the last two years due to vehicular/driver's characteristics of passenger cars. The results of seven most significant factors impacting the numbers of accident are given below:

Indicators Condition

It is quite evident from Figure 1 that one or more accidents occurred during the last two years for about 3 % instances due to non-working of one or both front indicators.

Presence of Any Damage

Figure 2 indicates that more than 4% vehicles were involved in one or more accidents during the last two years which have signs of damages on their bodies.
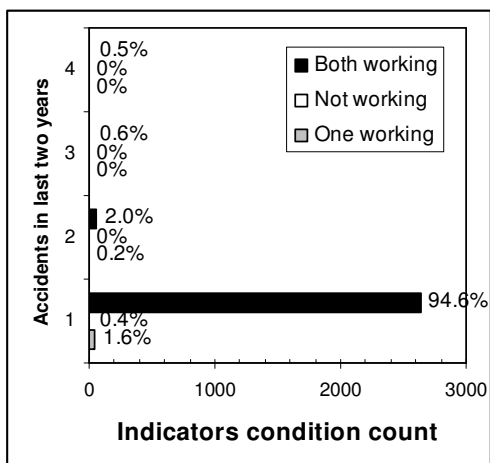

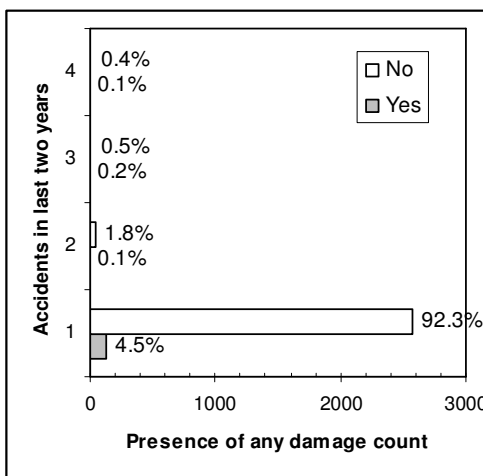Figure 1   Relation between number of accidents and indicators condition

Figure 2   Relation between number of accidents and presence of any damage
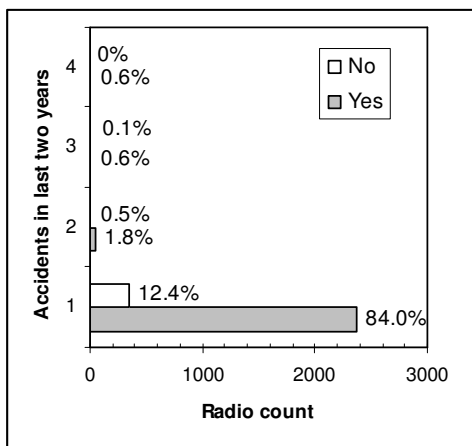

Figure 3   Relation between number of accidents and availability of musical instrument
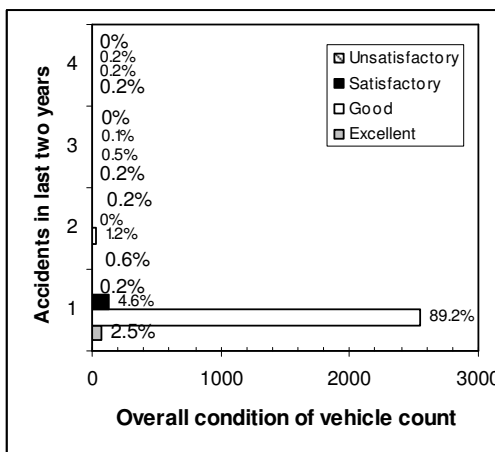

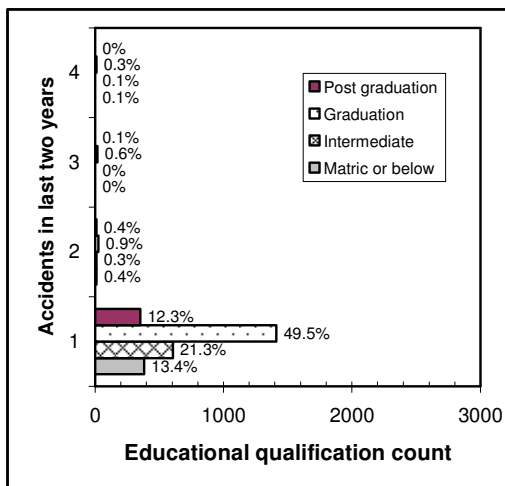Figure 4   Relation between number of accidents and vehicle condition

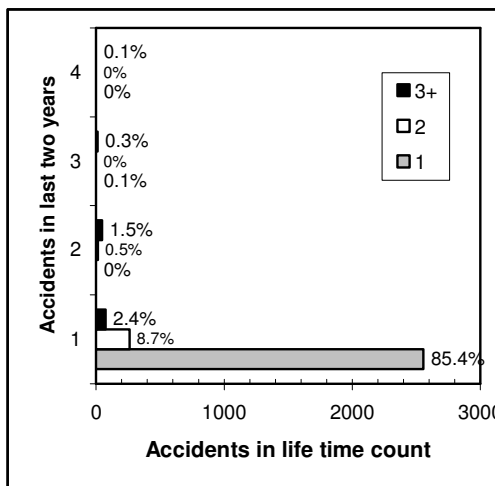Figure 5   Relation between number of accidents and qualifications

Figure 6   Relation between number of accidents and accident in life time
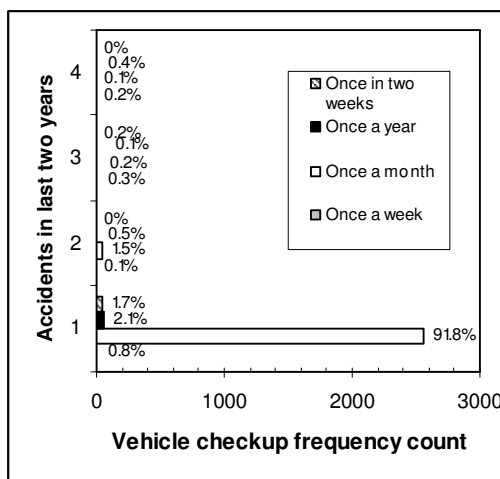

Figure 7   Relation between number of accidents and vehicle check-up

Musical Instrument

Figure 3 shows that majority of cars have radio available and majority of such cars were involved in one or more accidents during the last two years.

Vehicle Condition

Figure 4 indicates that at about 1% instances vehicles with overall unsatisfactory condition have been involved in one or more accidents. Even vehicles with good condition have been involved in accidents. It reflects that for such vehicles, the cause of accident may be some other factor.

Qualifications

Figure 5 shows that more than 13% people involved in accidents are with qualification matric or below. It is also evident from Figure 5 that well educated drivers may be involved in traffic accidents.

Accidents in Life Time

Figure 6 shows that more than 80% drivers have been involved in accidents during the last two years who were previously involved in such incidents in their driving experience.

Vehicle Check-up

It is quite evident from Figure 7 that most of the drivers claim that they take their vehicle for mechanical check-up once a month. More than 3% vehicles involved in accidents have vehicle check-up frequency of once a year.

From the aforementioned cross-tabulation analysis, it is quite evident that the traffic accidents do not depend on only one parameter. Rather their occurrence is affected by a number vehicular and driver's characteristics. This fact emphasizes the need to develop *APM* for passenger cars based on various significant vehicular and driver's characteristics.

ACCIDENT PREDICTION MODEL

For the development of model, contributions of seven most significant vehicular and drivers' characteristics have been identified using correlations method available in the *SPSS* software. The linear multiple regression analysis techniques has been employed to develop *APM* relating the number of accidents for two years (dependent variable) and seven most significant drivers and vehicular characteristics (independent variables) using the SPSS software. The model summary comprising R-squared, adjusted R-squared and standard error of estimate values for the linear regression analysis are respectively 0.961, 0.924 and 0.303 as shown in Table 1. Table 2 presents the output of the linear regression analyses for two years span using the *SPSS* software. In order to get the coefficient values for one year, the standardized coefficient values given in Table 2 were divided by 2. The products of coefficient values and the respective variables have been added and shown on the right side of equation 1.

Table 1 Model summary for passenger car

R*	R^2	Adjusted R^2	Standard Error of the Estimate
0.961	0.924	0.924	0.303

*: Pearson's correlation

Table 2 Coefficients (a) for passenger car

Variable	Standardized Coefficients	t-Value	p-Value
Condition of front indicators, Not working	0.002	0.304	0.761
Presence of any damage, left side front corner, Yes	0.387	38.593	0.000
Presence of musical instrument, Yes	0.259	25.996	0.000
Overall condition of vehicle, unsatisfactory	0.001	0.259	0.796
Educational qualification, primary	0.016	3.208	0.001
Accidents in life time	0.424	59.953	0.000
Number of times of routine checkup of vehicle, Once a year	0.008	1.484	0.138

a Dependent Variable: Accidents in Last Two Years

The Accident Prediction Model, with number of accidents per year as dependent variable and significant vehicular and drivers characteristics as independent variables is given below:

$$N_{a(PC)} = 0.0010V_1 + 0.1935V_2 + 0.0005V_3 + 0.2120D_1 + 0.1295D_2 + 0.0080D_3 + 0.0040D_4 \qquad (1)$$

where:

$N_{a(PC)}$: Expected number of accidents per year for passenger car

V_1: Condition of front indicators, not working

V_2: Presence of any damage, left side front corner, yes

V_3: Overall condition of vehicle, unsatisfactory

D_1: Number of accidents occurred in life time

D_2: Presence of musical instrument, yes

D_3: Educational qualification, Primary

D_4: Number of times of routine check-up of vehicles, once a year.
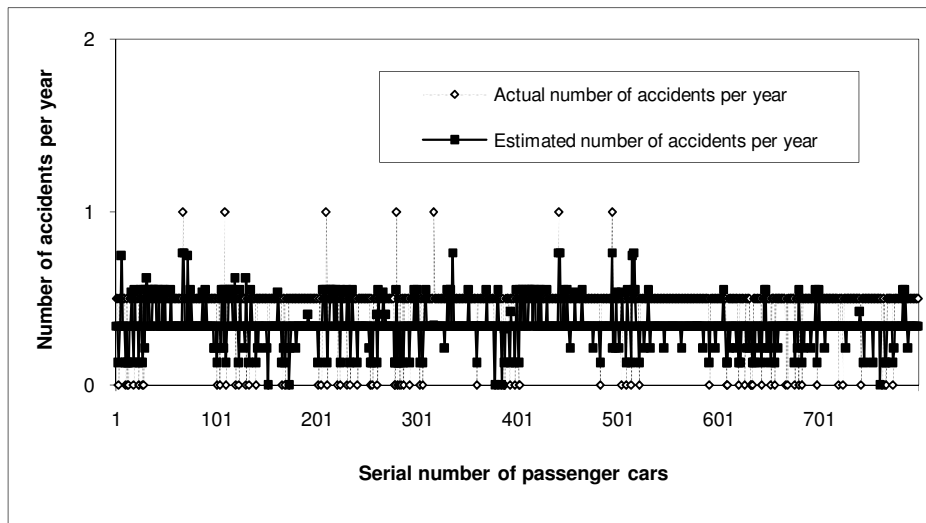

Figure 8 Verification of *APM* for passenger cars

VARIFICATION OF ACCIDENT PREDICTION MODEL

Sampling size of 3,800 Passenger Cars was taken, 3,000 for model development and 800 for its verification. For verification of the model shown by equation 1, the number of accidents per year was estimated using equation 1 for 800 passenger cars and compared with the actual number of accidents for the same passenger cars. Figure 8 presents this comparison. The estimated and actual numbers of accidents per year are in good agreement.

ACCIDENT PROPORTION OF MOST SIGNIFICANT VEHICULAR AND DRIVER'S CHARACTERISTICS OF PASSENGAR CARS

The damaged indicators, minor damages, overall unsatisfactory condition of cars, availability of musical instruments in cars, low qualification level, accidents committed by drivers in their entire

driving exposure and rare mechanical check-up of cars are the main causes of their accidents. The cross-tabulation analysis provides the following accident proportion of these characteristics:

Variable	Accident proportion (%)
Condition of front indicators, Not working	2
Presence of any damage, Left side front corner, yes	2
Presence of musical instrument, Yes	40
Overall condition of vehicle, Unsatisfactory	1
Educational qualification, Primary	5
Accidents in life time	41
Number of times of routine check-up of vehicle, Once a year	1

CONCLUSIONS

On the basis of aforementioned statistical analyses, the following conclusions drawn can be drawn from this study:

- The *APM* developed for passenger cars presented in Equation1 can be used in Lahore and other cities of Pakistan for:

  a. future forecasting of yearly number of accidents based on characteristics of vehicles and drivers contributing to accidents

  b. identification of the most significant characteristics of vehicles and drivers contribution to accidents on the basis of strength of correlations

  c. determination of accident proportions of most significant vehicular and driver's characteristics

  d. reduction in road accidents by giving due attention to the most significant vehicular and driver's characteristics based on their accident proportions

- The damaged indicators, minor damages, overall unsatisfactory condition of cars, availability of musical instruments in cars, low qualification level, accidents committed by drivers in their entire driving exposure and rare mechanical check-up of cars are the main causes of their accidents. The proportion of car accidents indicates that more than 90% accidents occurred due to human errors. The Motor Vehicle Examination Authority and Law Enforcing Agencies should periodically check the passenger cars in general and with reference to aforementioned seven variables in particular for ensuring the road safety.

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