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ACCIDENT PREDICTION ALONG AKURE-OWO HIGHWAY, ONDO STATE NIGERIA USING REGRESSION MODELS.

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Abstract:

Accident data on the 47.8km long Akure-Owo highway were collected and analyzed. The results show that 2511 persons were involved in the accidents, 180 persons were killed and 1059 injured between 2010 to 2015. 45% of the accidents were fatal and 55% non-fatal. There is a strong positive correlation between accidents that occurred due to the human factors. The relationship between the human factors and accident rate is statistically significant (r=0.981, p=0.000). Also, the relationship between accident rate and vehicle factor is also significant and the relationship is positive (r=0.682, p=0.000). For this study, vehicle and human factors were independent predictors considered for the analysis. Other factors such as environmental and road factors have a negligible Pearson Correlation Coefficient which is not statistically significant. Therefore, the model predicts the accident rate along the route (the dependent variable) based on independent variables which are human and vehicle factors. The chosen model is a strong model with R^2 of 0.998. That means 99.8% of the total number of accidents are explained by human factor (HF) and vehicle factors (VF).

Keywords: Accident data, human factors, vehicle factor, Pearson Correlation Coefficient, model

1. INTRODUCTION

Road traffic accident is an unexpected phenomenon that occurs as a result of the operation of vehicles including bicycles and handcarts on the public highways and roads. Accidents may be fatal, resulting in deaths of the road users (passengers, drivers or pedestrians), or minor when it is not severe enough as to cause substantial difficulty. Road traffic accident may also be defined as anything which happens by chance, anything occurring unexpectedly and un-designed [1]. Since road traffic accidents would rarely give warning, although reckless drivers should anticipate the consequences of their recklessness; human recklessness, carelessness or negligence should be avoided at all cost by road users. Traffic crashes and collisions could be prevented, and its effects can be minimized by modifying driver behaviour, vehicle design, roadway geometry, and by modifying the traveling environment. If the factors that have contributed to any traffic accident are identified, it is then possible to modify and improve the highway system. A safer highway system is likely to result with the reduction or elimination of crash causing factors [2, 3, 4].

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In developing countries, growth in urbanization and in the number of vehicles has led to increased traffic congestion in urban centers and increase in traffic accidents on road networks, which were never designed for the volumes and types of traffic that they are now to carry. There is also competition between different classes of road users coupled with poor road maintenance, bad and inadequate provision of road infrastructure. All these have contributed to the serious road safety problems in developing countries like Nigeria. The Global Burden on Disease Study undertaken by the World Health Organization (WHO), Harvard University and World Bank showed that in 1990 the traffic sector was assessed to be the world ninth most important health concern. It is forecasted that by the year 2020, road accidents would move up to third place as the leading cause of death and disability facing the world community.

In Nigeria today, hardly a day goes by without the occurrence of a road traffic accident leading to generally increasing incidence of morbidity and mortality rates as well as financial cost to both society and the individual involved. Information on some of these traffic accidents get to the news rooms of media houses and are aired while majority goes unreported. Nigeria has the highest road accidents rate as well as the largest number of deaths per 10,000 vehicles [5]. One may be tempted to believe that the level of awareness on the causes of road traffic accidents is very low among Nigerians. Put differently, Nigerian roads have become killing fields without protection for their users. Travellers heave a sigh of relief if they make their destinations [6]. Contrary to the general belief that Nigerians possess very low level of awareness on the causes of road traffic accidents, previous research has shown that Nigerians know quite a lot about the causes of road traffic accidents [7].

There are many causes for accidents. The human factor, the driver, is the primary cause of those accidents. The main cause of traffic accidents is disobeying the traffic safety laws, which include speeding, driver distraction, driving under the influence of drugs or alcohol, close following between the running cars, yielding for pedestrians and other vehicles etc. The causes of crashes are usually complex and involve several factors. The main factors can be divided into four separate categories: the driver, the vehicle, the roadway, and the environment [8, 4].

The causes of accidents being interplay of a variety of factors, the analysis of accident data presents formidable problems. Qualitative methods of analysis of accidents can provide insight into the causes that contribute to accidents and can often help to identify the black spots on the street system. More recently, emphasis has shifted to the application of statistical technique in planning and analyzing experiments into the effectiveness of accident prevention measure and development of accident models. Some of the statistical techniques are Regression methods, Poisson distribution and Chi square test for comparing accident data. This study laid emphasis on accident studies on the 47.8km long Akure-Owo road (a highway) in South West Nigeria; while, the primary objective of the study is to identify factors that contribute to the cause of accident and develop an accident prediction model for the road segment using regression technique.

2. LITERATURE REVIEW

Accident Prediction Models (APMs) have been used in different countries as a useful tool by road engineers and planners. An Accident Prediction Model (APM) is a mathematical formula describing the relationship between the safety levels of existing roads (that is, crashes, victims, injured fatalities, etc) and variables that explain this level (spot speed, road length, width, traffic volume, etc.) [9]. Mathematical models help highway agencies to select design standards that are essential to highway safety and to follow comparison among alternative designs that will optimize the overall safety of the highway system under limited resources and other constraints. These models can also be used to test sensitivity of accident rates to a specific geometric variable, vehicle factors and to combined roadway and vehicle factors [10]. Researchers and practitioners have made great efforts to improve traffic safety by applying design standards by highway agencies to ensure optimal operational and safety performance of roads. However, Road Traffic Crashes (RTCs) continue to be a major socio-economic problem for most developing countries [11, 12].

[13] developed accident prediction models for Akure-Ondo carriageway using multiple linear regression. Their analysis of spot speed indicated that higher value of 85th percentile contributed to the accident on the carriageway with a posted speed limit of 60km/hr; other contributing factors stated are drivers' behaviour; poorly maintained vehicles; non adherence to traffic rules; poorly maintained road and verges; and over-speeding.

[14] studied the prediction of the number of crashes versus the crash rate using Poisson regression. This type of regression was used to model both the crashes and crash rates. Small data sets for several intersections were used for this study. Several ways of modeling highway safety were investigated, including different representations of traffic exposure and intersection effects as independent variables.

[15], based on his study on accidents prevention, developed an accident model with subordinate variable of accident rates (by accident types) and independent variables of the whole width of shoulder, the width of lane, road vertical alignment and average daily traffic volume. The result showed that accident rate was decreasing with smooth vertical alignment, as road with less ADT, wider lane, and shoulder, has less accident rates.

[16] developed an accident model by road-grade for Florida State. The independent variables used were constant road length, AADT, the width of lane and shoulder, and the types and width of median barrier, existence of curve, speed limit, grade and the number of intersections. The result found that to widen the width of median barrier on the four-lane roads enhanced safety and roads with two-way and left-turn median barrier were safer than non-separation roads.

[17], developed traffic accident prediction models based on traffic and road characteristics in urban areas. They considered the characteristics of roadway alignments and traffic characteristics. The factors influencing accident rates were selected. Factors such as traffic volumes, intersections, connecting roads, pedestrian traffic signals, existence of median barrier and lanes were considered. In their study, roads were classified into four (4) groups based on lanes, road level and the existence of median barriers. Regression analysis was performed for each group with actual data associated with traffic, roads and accidents. A model was proposed for predicting accident-occurring possibilities of the sections according to the physical factors of the roads. Their results showed that in case of two lane roads, the number of intersections and pedestrian traffic signals are causative factors, and in case of the existence of four lane roads, median barrier and the number of connecting roads are causative factors.

[18] developed an accident prediction model according to each condition by distinguishing separation and non-separation of left-turn lane separating roads away from median separation facilities. As a result, they proposed that accidents were affected by AADT, length of roads, density and land use. [19] used simple linear regression and Poisson regression, with traffic and geometric characteristics as independent variables, to estimate truck accident rates. [20] proposed a Poisson regression model to establish empirical relationships between truck crash rates and highway geometric and traffic data. [21] developed a crash-prediction model that related crash rates to an Infrastructure Coefficient (IC) by

using Principal Component Analysis. This infrastructure coefficient was a linear weighted combination of several infrastructure characteristics.

3. THE STUDY AREA

The length of Akure-Owo road under study spans from Federal University of Technology Akure north gate to Rufus Giwa Polytechnic main gate Owo. The distance is about 47.8km. Twenty-four locations were selected for investigation based on Federal Road Safety Commission (FRSC) data from 2010 to 2015 and the existing conditions noticed during the survey. Selected accident vulnerable locations are as shown in the study area map of Figure 1 and Table 1 below.

Figure 1: GIS Map of the Study Area

Table 1: Accident Prone Locations Along Akure-Owo Highway

Locations	Year	Total Number of Accidents	Number of Persons Involved	Number Injured	Number Killed
FUTA North Gate	2010-2015	08	10	05	03
Akad/Wesco Estate	2010-2015	04	08	06	01
Oloko/Ibadan Park	2010-2015	08	17	10	01
Peace Park	2010-2015	04	05	01	04
Oyarugbulem	2010-2015	09	75	36	02
NNPC Mega Station	2010-2015	19	116	39	01
Seebi Filling Station	2010-2015	08	19	05	06
Olu foam	2010-2015	11	57	25	01
Mrs Filling Station	2010-2015	02	18	01	03
Ita Ogbolu	2010-2015	09	37	10	01
Benin Park	2010-2015	05	45	06	01
FGCC Akure	2010-2015	04	28	07	01
Shasha	2010-2015	12	107	46	02
Mobile Police Office	2010-2015	07	72	44	05
Airport Junction	2010-2015	08	199	102	06
High School Junction	2010-2015	07	59	69	06
Ilu Abo	2010-2015	08	38	24	02
Bolorunduro	2010-2015	12	254	48	04
Ogbese	2010-2015	79	594	238	76
Uso	2010-2015	24	196	97	23
Emure Uli	2010-2015	18	70	29	07
Rufus Giwa PolyGate 1	2010-2015	38	190	81	16
Rufus Giwa Poly. Main Gate	2010-2015	43	289	122	08

Source: FRSC (2015).

4. METHODOLOGY

i. Independent Variables

The relationships between the independent variables and accidents were clearly apparent from data collected from FRSC office. Independent variables selected for analysis were:

Human Factors- DTF- Driving Too Fast, DAD- Drinking and Driving, IED- Inexperienced Drivers, DWT- Driving When Tired, FVC- Following the Vehicle in Front too Closely, TMD- Taking Medicine and Driving, TDD- Taking Drugs and Driving, IRU- Impatience of Road Users, SAF- Sleepiness and Fatigue, DCE- Disobedience to Driving Code and Etiquette, LSB- Lack of Seat Belt, PSA- Passengers Attitude, UMH- Using a Mobile Phone (Hand Held) and Driving, UMF- Using a Mobile Phone (Hand Free) and Driving, VAD- Visual and Auditory Acuity of Drivers, DMA- Decision Making Ability, FPD- Faulty Preparation by Drivers.

Vehicle Factors- Poor Breaks/Break Failure (PBF), Bad Tyres (BAT), Burst Tyres (BUT), Defective Steering (DES), Faulty Light (FAL), Defective Horns (DEH), Faulty Gear Box (FGB), Absence of Rear View (ARV), Wind Shield i.e. Poor Visibility (WSP), Breakdown of Engine (BDE), Other Mechanical Failure (OMF).

Road Factors- intersection, spot speed, condition of shoulder, pavement condition, width of pavement, drainage condition, gradient of pavement, stopping sight distance, overtaking sight distance.

Environmental Factors- rain, dew, sunray, dusty weather, oily surface, mist and fog.

ii. Dependent Variable

The dependent variable is the accident rate/frequency.

iii. Variable Correlations

Identification of variable correlations is required to avoid having two or more significantly correlated variables in the same prediction model. In such cases the variability in one variable does, to a certain extent, predict the variability in the correlated variable. Table 2 shows the variable correlation with accidents rate.

Table 2: Variable Correlation

		Accident Rate	Human Factor	Vehicle Factor	Road Factor	Environmental Factor
Accident Rate	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	107				
Human Factor	Pearson Correlation	.981**	1			
	Sig. (2-tailed)	.000				
	N	104	104			
Vehicle Factor	Pearson Correlation	.682**	.570**	1		
	Sig. (2-tailed)	.000	.000			
	N	57	55	57		
Road Factor	Pearson Correlation	.220	-.002	-.109	1	
	Sig. (2-tailed)	.185	.988	.539		
	N	38	37	34	38	
Environmental Factor	Pearson Correlation	.414**	.203	.274	.560**	1
	Sig. (2-tailed)	.010	.222	.111	.000	
	N	38	38	35	35	38

**. Correlation is significant at the 0.01 level (2-tailed).

There is a strong positive correlation between accidents that occurred due to the human factors. The relationship between the human factors and accident rate is statistically significant (r=0.981, p=0.000). Also, the relationship between accident rate and vehicle factor is also significant and the relationship is positive (r=0.682, p=0.000). Relationship between environmental factor was as well significant to accident that occurred along the expressway but the relationship was very weak compared to human and vehicle factors (r=0.414, 0.010). While relationship between road factor and accident rate was not statistically significant (r=0.220, p=0.185). Human factors and vehicle factors contributed significantly to increase of accidents along the road examined for the survey. The correlation between the variables are highlighted in Table 2.

These correlations were considered in the models developed. Correlation between human and road factors and correlation between human and environmental factors were found to be small enough to be negligible. The correlation between human and vehicle factors was large and was taken into consideration when developing the models.

5. RESULTS AND DISCUSSION

Model Development

Regression Model on Accident Rate along Akure-Owo Highway Based on Human and Vehicle Factors.

Linear Regression estimates the coefficients of the linear equation, involving one or more independent variables that best predict the value of the dependent variable. For this study, vehicle and human factors were independent predictors considered for the analysis. Other factors such as environmental and road factors have a negligible Pearson Correlation Coefficient which are not statistically significant. Therefore, the model predicts the accident rate along the route (the dependent variable) based on independent variables which are human and vehicle factors.

The linear regression model assumes that there is a linear relationship between the dependent variable and each predictor. This relationship is described in equation 1 below.

$$Y_i = \alpha + \beta_i X_i + \beta_j X_j + \ldots + \beta_{ij} X_{ij} + e_i \quad (1)$$

Where

Y_i is the value of the ith case of the dependent scale variable
X_i is the number of predictors
β_j is the value of the jth coefficient
$X_i j$ is the value of the ith case of the jth predictor
e_i is the error in the observed value for the ith case

Regression Model Calibration

The model developed was verified by using it to predict accidents occurrence at each location and comparing the outcome with the observed accidents.

Regression Models between the Total Number of Accidents Y_1 and the Independent Variables for all the Locations.

The SPSS software output are shown in Tables 3, 4 and 5. Model number 1 was selected as shown below. This model relates the number of accidents with the following independent variables:
HF = Human factors
VF = Vehicle factors.

Table 3: Regression Model and its Adjusted R^2 Value

Model No.	Regression Model	Adjusted R^2
1	$Y_i = 0.078 + 0.997HF + 0.986VF \ + e_i$	0.998

The chosen model is a strong model with R^2 of 0.998. That means 99.8% of the total number of accidents are explained by HF and VF. The relationship between the dependent variable and the independent variables is directly proportioned as expected.
The ANOVA Table 5 reports a significant F statistic, indicating that using the model is better than guessing the mean. As a whole, the regression does a good job of modeling accident rate. The coefficient of determination R^2 = 0.998 in Table 4 shows that 99.8% of the variation in accident along the route is explained by the model. This implies that 99% of the human and vehicle factors accounted for accident that occurred along the route.

Table 6 shows the coefficients of the models, the relationship between human factor and accident along the route is statistically significant (t=125.556; p-value=0.000). Relationship between vehicle factor and accident rate is also statistically significant.

Table 4: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.999	.998	.998	.232

Table 5: ANOVA

Model	Sum of Squares	df	Mean Square	F	P-value
Regression	1666.588	2	833.294	15511.351	0.000
Residual	2.794	52	.054		
Total	1669.382	54			

Table 6: Coefficients

Dependent Variable: Accident Rate	Unstandardized Coefficients		Standardized Coefficients	t	P-value
	Beta	Std. Error			
(Constant)	0.078	0.041		1.913	0.061
Human Factor	0.997	0.008	0.867	125.556	0.000
Vehicle Factor	0.986	0.033	0.206	29.830	0.000

To determine the black spots or the most Hazardous and dangerous locations for all the study area. This step was done by comparing the actual number of accidents on each location with the predicted numbers of accidents by using the predicted regression model from the SPSS Software. The difference between the actual number of accidents and the predicted number of accidents are calculated. Then, the results are sorted in descending order. The location with the highest difference value is considered as the most hazardous location and is given the priority in the suggested treatment. The results of applying model 1 are shown in Table 7.

Table 7: Rank of the Hazardous Locations in the Study Area

Rank	Location Name	Actual Accidents (HF&VF)	Predicted Accidents (HF&VF)	Difference	Percentage Difference
1.	Ogbese	75	74.743	0.257	0.34
2.	Rufus Giwa poly second gate	37	36.835	0.165	0.45
3.	Rufus Giwa poly main gate	42	41.908	0.092	0.22
4.	Mrs Filling Station	02	2.072	0.072	3.47
5.	Akad/Wesco	04	4.066	0.066	1.62
6.	Peace Park	04	4.066	0.066	1.62
7.	FGGC Akure	04	4.066	0.066	1.62
8.	Benin Motor Park	05	5.063	0.063	1.24
9.	Airport Junction	07	7.057	0.057	0.81
10.	FUTA North gate	08	8.054	0.054	0.67
11.	Mobile Police Office	07	7.046	0.046	0.65
12.	High Sch. Junction	07	7.046	0.046	0.65
13.	Oloko/Ibadan Park	07	7.046	0.046	0.65
14.	Shasha	12	12.042	0.042	0.35
15.	Uso	24	23.962	0.038	0.16
16.	Seebi Filling Station	07	7.035	0.035	0.50
17.	Olu Foam	11	11.034	0.034	0.31
18.	Bolorunduro Junction	11	11.034	0.034	0.31
19.	Ilu Abo	08	8.032	0.032	0.40
20.	Road block	12	12.031	0.031	0.26
21.	Itaogbolu Junction	09	9.029	0.029	0.32
22.	Oyarugbulem	09	9.018	0.018	0.20
23.	Emure Uli	17	16.994	0.006	0.04
24.	NNPC Mega Station	19	18.999	0.001	0.53

The results of applying the models are shown in Table 7. The percentage difference specifies the percentage increase of the recorded crashes vs the predicted. A result of 10% means the model is over predicting crashes by 10%, while -0.04% means the model is under predicting crashes by -0.04%.

6. CONCLUSION

The road traffic crashes that have been on the increase over the years on Akure-Owo highway were due to four contributing factors: human, vehicle, road and environmental factors. The most significant of these factors are the human and vehicle factors, as the linear model developed gave the coefficient of determination $R^2 = 0.998$ indicating that 99.8% of the variation in accident along the route is explained by the model. This implies that 99% of the human and vehicle factors accounted for accident that occurred along the route. Parameters of these factors involved were over speeding, drinking and driving, inexperience drivers, break failure and bad tyres.

7. RECOMMENDATIONS

The following recommendations are made to reduce the rate of accident on Akure-Owo road based on the two most significant factors:
Human factors:

- Sanitation of motor parks from alcohol sales and consumption with establishment of Body Alcohol Content (BAC) sobriety checks points. Shops where alcoholic beverages are sold are visibly present in most if not all Nigerian motor parks today without recourse to the very negative effects of drunk drinking by drivers who are the main consumers. The resultant effect is reckless driving on our Highways. There is need for enactment of legislations to address this issue and thorough enforcement of legislation already put in place forbidding the sale of alcoholic drinks or beverages in our motor parks. More so, laws that establish BACs of 0.05g/dl or below are effective at reducing the number of alcohol-related crashes. Enforcing sobriety checkpoints and random breath testing can lead to reduction in alcohol-related crashes of about 20% and have shown to be very cost-effective.
- Education – more emphasis must be put on education and training, not only for drivers but for all potential road users. Assessment should always be carried out to ensure that drivers are better qualified.
- Laws and Enforcement - all established agencies such as Federal Road Safety Commission, FRSC and Vehicle Inspection Offices, VIOs in collaboration with union bodies like the Nigerian Union of Road Transport Workers, NURTW should enact and enforce laws concerning human behaviour while driving.

Vehicle factors:

- Ensuring proper vehicular morning parades- vehicle drivers should adequately ensure that they check every part of their vehicles to ensure that they are in good condition before putting them into use on Nigerian roads. Before driving a vehicle for the first time every day, adequate effort should be made to check the radiator water level, brake hydraulic fluids and that of clutch for manual vehicles, level of oil in engine, fan blades, engine belts and tyre gauge, every morning while the vehicle is put on and allowed to run idle for a few minutes.
- Diligence of duty by government established agencies- established agencies such as Federal Road Safety Commission, FRSC and Vehicle Inspection Offices, VIOs must carry out their jobs effectively and thoroughly; checking the conditions of vehicles that ply the roads, without extorting money or collecting bribes from drivers.
- Establishment of vehicle standards- the federal government and all agencies concerned with road transportation should make it a point of duty by establishing standards for vehicle manufacturing and testing, develop and apply safety accessories of vehicles e.g. dualline brake system and seat belts and impose compulsory motor vehicle inspection regulations.

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