Journal of Multidisciplinary Engineering Science Studies (JMESS)
ISSN: 2458-925X
Vol. 7 Issue 6, June - 2021

Modelling Road Traffic Crash Variables in Anambra State, Nigeria: An Application of Negative Binomial Regression

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***Abstract*— Incessant road traffic crashes with attendant injuries and deaths to road users have been a thing of serious concern to all stakeholders in low-middle-income countries including Nigeria. This study analyzed the causes of road traffic crashes in Anambra State, Nigeria with the intention of determining significant factors affecting road traffic crashes in the State using negative binomial regression model. The result revealed that: over speeding, use of mobile phone while driving, loss of control, dangerous driving, brake failure, tyre failure/burst, bad road, sleeping on steering, wrongful overtaking, road obstruction and weather condition are the statistical significant factors influencing road traffic crashes in Anambra State, Nigeria. The analysis of the residual and likelihood ratio showed that the model is robust in describing crash situations in the State. The outcome of this study will help road safety agency in the State in understanding the significant crash contributing factors, their effects, and in developing effective and efficient countermeasures that can help in curbing crash occurrences in the State.**

Keywords—Road traffic crashes; Negative binomial regression; Crash contributing factors; Anambra State; Nigeria

I. INTRODUCTION

The rate of road traffic crashes with their attendant injuries and deaths on the roads has been the major concern of everybody world over. WHO (2015) estimated that over 1.2 million people die each year on the world's road, with millions more sustaining serious injuries and living with long-term adverse health consequences. Ninety-percent of these deaths occur in low- and middle-income countries including Nigeria [1].

To improve road safety and reduce incessant loss of lives on roads, many research efforts have been conducted to investigate the factors influencing road traffic crashes in different countries using different methodological approaches [2,3,4,5,6,7,8,9,10]. Owing to overcoming the problem of over-dispersion which is mostly associated with crash count dataset, negative binomial model has been widely used to establish the relationship between crash frequency and the likely factors that influence crash occurrences on the roads [7,11,12,13,14,15].

The outcome of some of these studies in the developed countries have led to development of various crash prediction models, which have been useful in different countries for road designers, engineers, planners and safety personnel in ensuring the safety of the roads [7,16,17]. However, [18] stated that it would neither be valid nor useful to apply simple multiplicative factors or device more complex conversion formula for models developed in one country for another country due to wide differences in traffic mix, road quality design and road users' behavior. This implies that a unique crash predictive model is needed for each country or geographical location.

In Nigeria, different studies have tried to model the causes of road traffic crashes in different parts of the country considering different contributing factors [19,20,21,22,23,24,25,26,27,28]. Reference [23] analyzed road traffic crashes in Lagos State, Nigeria considering length of road, presence of Federal Road Safety Corps (FRSC) and population as the crash contributing factors. Reference [24] employed linear regression analysis in analyzing the regional determinants of road traffic crashes in Nigeria using the total population, the State's degree of urbanization, the gross domestic product per capita per State, the number of financial institutions per State, the traffic density per State, the length of federal roads in per State, the length of asphalt concrete roads in per State, the length of gravel roads in per State, and the length of surface roads in per State as the predictive variables. Reference [25] examined factors contributing to road traffic crashes in Ekiti State, Nigeria using linear regression analysis and found that over speeding (speed violation), drivers' distraction and dangerous overtaking contribute significantly to road crashes in the State. Reference [26] studied the impact of weather (rainfall and temperature) on road traffic crashes in Ondo State, Nigeria between 2005 and 2012, and found that the correlations between road traffic crashes and

elements of weather were generally low and never exceeding 0.41. Reference [28] developed parametric models for road traffic crashes prediction at specific locations along Ado Ekiti–Ikole Ekiti Road in Ekiti State Nigeria, considering spot speed, pavement condition, condition of the shoulder, width of the road, elevation/cambering, gradient and crash vulnerability as the factors contributing to the crashes.

However, most of these studies in Nigeria applied multiple linear regression analysis in developing causal relationships between number of crashes and the contributing factors. But, multiple linear regression is suitable for continuous data and unsuitable for dealing with number of crash data [29]. This is because number of crashes is a count dataset with unique properties such as randomness, discreteness and is non-negative.

Although many studies have been conducted to investigate various factors influencing road traffic crashes in Nigeria, much work is still needed more especially in the area of using appropriate mathematical modelling techniques since that is the only way to get more reliable results. The objective of this study is to examine the relationship between road traffic crashes and their contributing factors in Anambra State. This study employs Negative binomial (NB) regression in modelling the causes of road traffic crashes in Anambra State, Nigeria. The result of this study will help road safety agency in the State in understanding the significant crash contributing factors in the State and in developing effective and efficient countermeasures that can help in curbing road traffic crashes in the State.

The rest of the paper is organized as follows. Section 2 describes the data sources used for the analysis. Section 3 covers the methods used in data analysis. Section 4 presents the results and discussion of the findings. Section 5 presents the conclusion and recommendation.

II. RESEARCH METHODOLOGY

A. Data Description

The data used for this study were obtained from the records of the Federal Road Safety Commission (FRSC) Anambra State Sector Command, Awka. The Federal Road Safety Commission (FRSC) is the government agency in Nigeria with statutory responsibilities for road safety administration. Among the various roles of FRSC are giving prompt attention and care to victims of crashes, carrying out thorough investigation on the remote and immediate contributing factors to road crashes and filing their reports. They gather the crash information through on the spot assessment of crash scenes, vehicle, environmental conditions, and thorough interviews of the crash victims (drivers and passengers or pedestrians) and onlookers. The records contain information on the types of road crashes, crash severity (fatal, serious and minor), categories of road users involved, vehicle type, number of vehicles involved, number injured, number killed, causes of crashes, date and time of occurrence, location among other things. The reports record crashes that accounted for at least one minor injury. This study covered road traffic crashes in the whole State, from 2005 to 2015, 1675 road crashes.

Each crash observation comprises a number of attributes (explanatory variables) relating to the victims of the crash, vehicle, and roadway and environmental conditions as judged by the investigating officers. The contributing factors to road traffic crashes as recorded by FRSC and used in this study are: over speeding (over speeding), use of mobile phone while driving, tyre failure/burst, loss of control, mechanically deficient vehicle, wrong overtaking, brake failure, overloading, dangerous overtaking, dangerous driving, bad road, route violation, road obstruction, sleeping on steering, driving under the influence of alcohol and drugs, poor weather (moderate and heavy rainfall), fatigue (FTQ) and sign light violation (SLV). The descriptive statistics of the variables both the response variable (number of crashes) and the predictive variables (explanatory variables) are shown in Table 1. The maximum monthly crash count is 41, mean of 12.73 crashes occurred every month with standard deviation of 9.885. From Table 1, it can be seen that the variance (9.885^2 = 97.713) exceeds the mean (12.73) number of crashes showing over-dispersion in the dataset.

Table 1: Descriptive Statistics of the Variables

Variable	Minimum	Maximum	Mean	Std. Deviation
Number of Crashes	0	41	12.73	9.885
Over Speeding (Speed Violation)	0	17	4.12	3.752
Use of Mobile Phone while driving	0	1	0.07	0.253
Tyre Failure/burst	0	5	0.74	1.046
Loss of Control	0	17	2.50	3.340
Mechanical Deficient Vehicle	0	2	0.23	0.488
Wrong Overtaking	0	6	0.47	0.984
Brake Failure	0	8	1.47	1.830
Overloading	0	2	0.08	0.304
Dangerous Overtaking	0	5	0.58	0.865
Dangerous Driving	0	11	2.42	2.338
Bad Road	0	2	0.16	0.443
Route Violation	0	8	0.71	1.220
Road Obstruction	0	3	0.29	0.586
Sleeping on Steering	0	1	0.01	0.087
Driving under the influence of Alcohol and Drug	0	4	0.30	0.651
Weather Condition	0	5	0.17	0.568
Fatigue	0	1	0.05	0.209
Sign Light Violation	0	4	0.28	0.702

B. Methods of Data Analysis

Poisson and negative binomial regression models have been the most popular approaches used in investigating the relationships between the number of crashes and various crash contributing factors in the recent years [30,31]. The Poisson model is given by [32];

$$E(y_i) = \mu_i = \exp(x'_i \beta) \quad (1)$$

Where: y_i is the observed number of crashes for $i = 1,2,\dots,n$, x_i is the vector of the explanatory variables, β is the vector of parameters, μ_i is Poisson mean parameter.

The probability function, P can be given as;

$$P(y|\mu) = \frac{e^{-\mu}\mu^{y}}{y!}(y \geq 0) \quad (2)$$

The major limitation of Poisson regression model is that the variance of the data is confined to be equal to the mean. That is, $Var(y_i) = E(y_i)$. When this property is not supported by the data, it is said to be either under-dispersed $Var(y_i) < E(y_i)$ or as is usual for the road crash data over-dispersed $Var(y_i) > E(y_i)$ [30,31]. The issue of over-dispersion in a dataset can be addressed by using the negative binomial regression which allows for variance to be proportional to the mean with a constant proportionality exceeding unity.

The negative binomial model is derived by rewriting (1).

$$E(y_i) = \mu_i = Z_i \exp(x'_i \beta) \quad (3)$$

Where: Z_i is a gamma-distribution error term with mean 1 and variance α^{-1}. The parameter α corresponds to the over-dispersion parameter of a negative binomial distribution. The inclusion of this term allows variance of y to exceed its mean. Thus,

$$Z \sim Gam(\alpha),\ E(Z) = 1,\ Var(Z) = \alpha,\ E(y_i) = \mu_i$$
$$Var(y_i) = E(y_i)[1 + \alpha\mu_i] = \mu_i + \alpha{\mu_i}^2$$

The probability density function for negative binomial distribution has the form [43];

$$P(y|\alpha,\mu) = \frac{\Gamma(y_i+\alpha^{-1})}{\Gamma(y_i+1)\Gamma(\alpha^{-1})}\left[\frac{\alpha^{-1}}{\alpha^{-1}+\mu_i}\right]^{1/\alpha}\left[\frac{\mu_i}{\alpha^{-1}+\mu_i}\right]^{y_i} \quad (4)$$

Where $\Gamma(\cdot)$ is the gamma function.

The negative binomial regression coefficients in (2) are estimated using the method of maximum likelihood. The method is explained in details in [33].

III. RESULTS AND DISCUSSION

The analysis of the data collected was done using SPSS version 22 and the results are discussed in this section. Table 2 provides the test of the model as a whole (Omnibus Test). The likelihood ratio chi-square test provides a test of the overall model comparing this model to a model without any explanatory variables (the intercept-only model). It can be seen from the table that having the explanatory variables in the model gives a statistically significant (p-value is <0.0001) overall model, indicating a significant improvement over such a model with intercept-only.

Table 2: Omnibus Test

Likelihood Ratio Chi-Square	DF	p-value
207.245	19	<0.0001

Table 3 shows the parameters estimates of the negative binomial regression model at 95% confidence interval using 18 factors identified to be contributing factors of road traffic crashes in the State as the explanatory variables and the number of crashes as the response variable. The table contains the coefficients (the "B" column) of negative binomial regression and the exponentiated values of coefficients (the "Exp (B)" column), that is, the incidence rate ratio (IRR) for each of the predictor variables along with their standard errors, Wald chi-square values, and the p-values.
From Table 3, over speeding (speed violation) has a positive and significant contribution ($p < 0.0001$) to road crashes in the State. The Exp (B) = IRR of 1.077 in Table 3 shows that over speeding increases the mean number of crashes in the State by a factor of 1.077. In terms of percentage change, a unit change in over speeding changes the mean number of crashes by 7.7%. That is, % change = 100(1.077 – 1) = 7.7%. Excessive speeding triggers road traffic crashes with their attendant injuries and fatalities. This is consistent with the previous studies [25,34].

The use of mobile phone while driving (UPWD) has been found to cause a decrease in brake reaction time [35]. UPWD has a positive and statistical significant ($p = 0.041$) contribution to road crashes in the State with exponentiated value of coefficient (Exp(B)) of 1.187 showing that a unit increase in UPWD increases number of crashes in the state by factor of 1.188 (18.8%). This is in line with previous studies on use of mobile phone while driving [35]. Reference [35] findings indicate that mobile phone usage and driving compete for mental resources rather than for manual response.

Road obstruction (OBS) contributes significantly to road crashes in the State ($p = 0.002$). This shows that continued obstruction of roads by damaged vehicles, construction workers, and other environmental obstacles have been contributing positively to road crashes in the State. A unit increase in OBS leads to 1.103 times increase in the number of crashes in the State. This is consistent with the findings of [36] in Ghana.

Tyre Failure/burst (TFB) has been found to have a positive and significant contribution ($p < 0.0001$) to road crashes. The positive coefficient of TFB in Table 3 shows that tyre failure is a leading cause of road traffic crashes in the State. A unit increase in TFB results to increase in road crashes in the State by a factor of 1.073 (7.3%), other factors remaining constant. Tyre failure which may be caused by tyre over-inflation, under-inflation, excessive wear and overloading of vehicles, have been found to be a leading contributing factor in previous studies [37].

Brake failure (BFL) is significant factor affecting road traffic crashes in the State ($p = 0.001$). A unit change in BFL results to 1.064 times (6.4%) increase in the number of crashes in the State. Reference [38] also found brake failure as a significant contributing factor in road traffic crashes.

Loss of control is a significant factor influencing road crashes in the State ($p < 0.0001$). The LOC with Exp(B) value of 1.064 in the table 3 above indicates that the number of crashes in the State is 1.064 times greater for any extra loss of control. This is consistent with the study of [39] that found loss of control of vehicles as one of the most significant contributing factors that increase crash severity in urban highways.

Weather condition, in this case rainfall (crashes that occurred because of moderate and heavy rainfall), is also found to have positive and significant effects on road accidents in the state ($p = 0.016$). Excessive rainfall could lead to poor visibility, rivers overflowing their banks, roads flooding among other things, and this often times lead to crashes. This is consistent with the findings of [40,41].

Other factors that have significant effects on road traffic crashes in the State as can be seen in the table 3 are sleeping on steering ($p < 0.0001$), dangerous driving ($p < 0.0001$), wrong overtaking ($p = 0.011$) and bad road ($p = 0.008$). A unit increase in any of the factors increases the number of crashes in the State. An increase in sleeping on steering increases the number of crashes by 35.5%; an increase in dangerous driving increases it by 5.5%; wrong overtaking by 5%; and bad road by 10.8%. This is consistent with the findings of [42] that found wrong overtaking, bad road, and tyre burst among the significant factors that contribute to motorcycle crashes in Oyo State, Nigeria.

On other hand, mechanical deficient vehicle, overloading, dangerous overtaking, route violation, driving under the influence of alcohol and drugs, wrong turning, fatigue and sign light violation were found to be statistically insignificant, their p-values are greater than 0.05 in each case.

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Table 3: Parameter Estimates

Parameter	B	Std. Error	Hypothesis Test			Exp(B)
			Wald Chi-Square	Df	p-value	
(Intercept)	1.386	0.0645	461.255	1	<0.0001	3.997
Over speeding	0.074	0.0072	104.921	1	<0.0001	1.077
Use of phone while driving	0.172	0.0841	4.182	1	0.041	1.188
Tyre failure/burst	0.071	0.0185	14.737	1	<0.0001	1.073
Loss of control	0.062	0.0104	35.930	1	<0.0001	1.064
Wrong overtaking	0.049	0.0193	6.436	1	0.011	1.050
Brake failure	0.058	0.0183	10.111	1	0.001	1.060
Overloading	0.091	0.0731	1.541	1	0.214	1.095
Dangerous driving	0.054	0.0107	24.843	1	<0.0001	1.055
Bad road	0.102	0.0374	7.468	1	0.006	1.108
Road obstruction	0.098	0.0323	9.273	1	0.002	1.103
Sleeping on steering	0.304	0.0717	17.962	1	<0.0001	1.355
Driving under alcohol and drug	0.057	0.0334	2.910	1	0.088	1.059
Weather Condition	0.061	0.0252	5.820	1	0.016	1.063
Route violation	0.045	0.0251	3.241	1	0.072	1.046
Sign light violation	0.024	0.0325	0.531	1	0.466	1.024
Fatigue	0.099	0.0844	1.371	1	0.242	1.104
Dangerous overtaking	-.008	.0380	.039	1	.843	.992
Mechanical deficient vehicle	.061	.0402	2.267	1	.132	1.062
(Negative binomial)	2.922E-8	.				

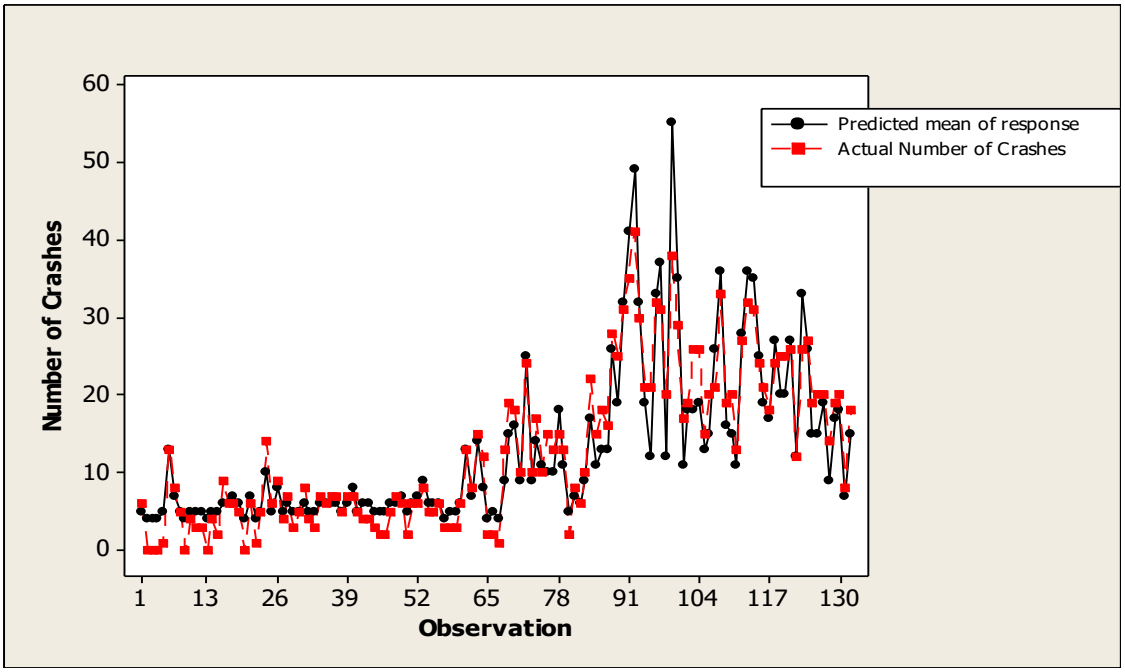

Fig. 1: Comparison of Predicted Mean Response and Actual Response

Fig. 1 shows the comparison of the predicted number of crashes (predicted mean response) and the actual number of crashes. The blue line shows the actual number of crashes and the red line shows the predicted values of the number of crashes. It can be seen from fig. 1 that the predicted values by negative Binomial regression model are closer to the actual values showing the prediction accuracy of the generated model. This implies that the model is good enough in predicting road crashes in Anambra State, Nigeria.

Fig. 2 shows the plot of the standardized deviance residual and the predicted value of mean of the response. From fig. 2, there are no significant deviations away from 0.000, and 100% of the residuals are under the absolute value of 2.000 (that is, between −2 and +2). This shows that the model fits the data very well.

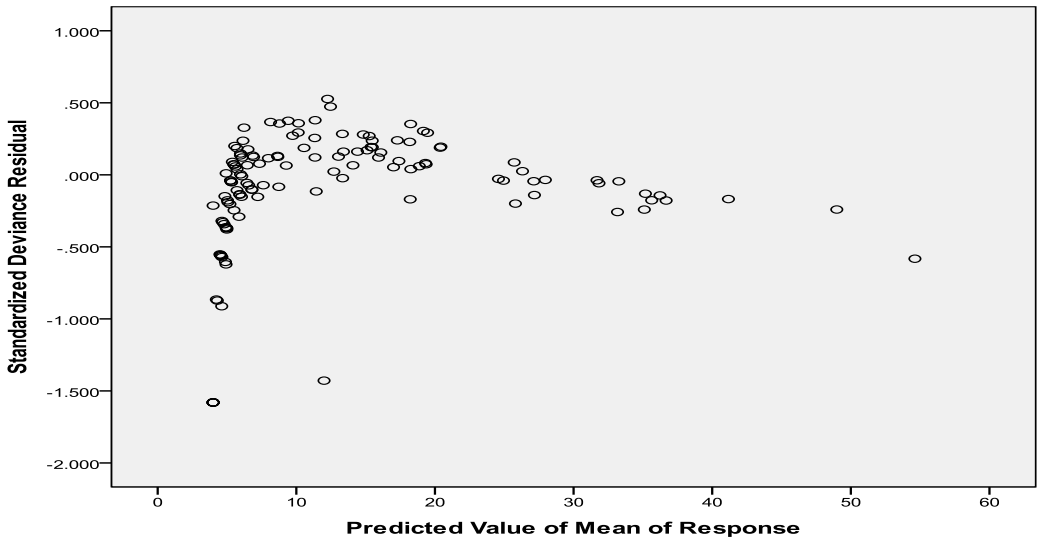

Fig. 2: Standardized Deviance Residual versus Predicted Value of Mean of Response

IV. CONCLUSION

This study has analyzed the contributing factors to road traffic crashes in Anambra State, Nigeria using crash count data from Federal Road Safety Corps Anambra State Sector Command. The effects of speed violation, use of mobile phone while driving, loss of control, brake failure, tyre failure/burst, bad road, sleeping on steering, dangerous or reckless driving, wrong overtaking, mechanically deficient vehicle, road obstruction, driving under the influence of alcohol and drugs, sign light violation, dangerous overtaking, fatigue, poor weather condition, route violation and overloading on the number of crashes were investigated using negative binomial regression model. The result revealed the following:

- Speed violation, use of mobile phone while driving, loss of control, brake failure, tyre failure, dangerous or reckless driving, wrongful overtaking, sleeping on steering, bad road, road obstruction and weather condition were statistically significant, each has its p-value less than 0.05. A unit increase in any of the factors will increase the number of crashes in Anambra State.
- Sign light violation, overloading, fatigue, dangerous overtaking, route violation, mechanically deficient vehicle, wrongful turning and driving under the influence of alcohol and drugs were statistically insignificant, each has its p-value greater than 0.05.
- The negative Binomial regression model generated is adequate or good fit for describing road crashes in Anambra State based on the analysis of the residuals.

The findings of this study would be useful to all stakeholders – road users, roadway designers and road construction companies, law enforcement agencies and policy makers in that they are in a better position to affect a variety of factors, hence, influencing road traffic safety. This study recommends total enforcement of all traffic laws and policies regarding speed limit, use of mobile phone while driving, road worthy vehicles and other factors identified to have significant effects on road crashes in the State. Federal Road Safety Corps should invigorate its safety campaign and education more especially as it concerns dangerous driving, using mobile phone while driving, wrongful overtaking, vehicle maintenance, among other things to ensure road safety in the State. Government at various levels should intensify efforts in road maintenance and rehabilitation as bad road is one of the leading contributing factors to road crashes in Nigeria.

One of the limitations of this study is that only crash count data from one State in Nigeria were used in the crash analysis and prediction. The future research effort in this regard should involve extending the research to the entire country and other developing countries and investigating the impact of other crash contributing factors such as demographic factors.

REFERENCES

[1] World Health Organization, Global Status Report on Road Safety 2015, Geneva: World Health Organization, 2015.

[2] M. Abdel-Aty, “Analysis of Driver Injury Severity Levels at Multiple Locations using Ordered Probit Models”, Journal of Safety Research, Vol 34, No. 5, pp 597-603, 2003.

[3] J. Aguero-Valverde and P.P. Jovanis, “Spatial Analysis of Fatal and Injury Crashes in Pennsylvania”, Accident Analysis and Prevention, Vol 38, pp 618-625, 2006.

[4] F.W.Y. Wan, A.L. Mohamad and B.W. Yep, "Modelling Road Accidents using Fixed Effects Model: Conditional versus Unconditional Model", Proceedings of the World Congress on Engineering 2012, Vol 1, WCE 2012, London, June 2012.

[5] B.R.D.K. Agbelie, "Random-Parameters Analysis of Highway Characteristics on Crash Frequency and Injury Severity", Journal of Traffic and Transportation Engineering (English Edition), Vol 3, No. 3, pp 236-242, 2016.

[6] P. Saha, K. Ksaibati, "An Optimization Model for Improving Highway Safety", Journal of Traffic and Transportation Engineering (English Edition), Vol 3, No. 6, pp 549-558, 2016.

[7] Z. Ma, H. Zhang, S.I. Chien, J. Wang, C. Dong, "Predicting Expressway Crash Frequency using a Random Effect Negative Binomial Model: A Case Study in China, Accident Analysis and Prevention, Vol 98, pp 214-222, 2017.

[8] C.C. Ihueze and Onwurah U.O., "Tracking and and Appraisal of Road Traffic Accidnts: An Analysis for Anambra State, Nigeria", Journal of Engineering and Applied Sciences, Vol 13, pp 12-24, 2018.

[9] C.C. Ihueze and Onwurah U.O., "Road Traffic Accidents Prediction Modelling: An Analysis of Anambra State, Nigeria", Accident Analysis and Prevention, Vol 112, pp 21-29, 2018.

[10] F.M.A. Hassouna and K. Al-Sahili, "Practical Minimum Sample Size for Road Crash Time-Series Prediction Models", Advances in Civil Engineering

[11] M. Abdel-Aty and E. Radwan, "Modelling Traffic Accident Occurrence and Involvement", Accident Analysis and Prevention, Vol 32, No. 5, pp 633-642, 2000.

[12] D.J. Graham and S. Glaister, "Spatial Variation in Road Pedestrian Casualties: The Role of Urban Scale, Density and Land-use Mix", Urban Studies, Vol 40, No. 8, pp1591-1607, 2003.

[13] Y. Kweon and K.M. Kockelman, "Spatially Disaggregate Panel Models of Crash and Injury Counts: The Effect of Speed Limits and Design", Presented at 83rd Annual Meeting of the Transportation Research Board, January 2004.

[14] M.A. Quddus, "Time Series Count Data Models: An Empirical Application to Traffic Accidents", Accident Analysis and Prevention, Vol 40, pp 1732-1741, 2008.

[15] C. Wang, M.A. Quddus and S.G. Ison, "Impact of Traffic Congestion on Road Accidents: A Spatial Analysis of the M25 Motorway in England", Accident Analysis and Prevention, Vol 41, pp 798-808, 2009.

[16] D.J. Houston, L.E. Richardson, "Traffic Safety and the Switch to a Primary Seat Belt Law: The Califonia Experience", Accident Analysis and Prevention, Vol 34, pp 743-751, 2002.

[17] R.B. Noland, M.A. Quddus, "Improvements in Medical Care and Technology and Reductions in Traffic-related Fatalities in Great Britain", Accident Analysis and Prevention, Vol 36, pp 103-113, 2004.

[18] J.P. Fletcher, C.J. Badguley, Sexton B., S. Done, "Road Accident Modelling for Highways Development and Management in Developing Countries", Main Report: Trials in India and Tanzania, Project Report No.: PPR095, 2006.

[19] O.J. Oyedepo and O.O. Makinde, "Accident Prediction Models for Akure-Ondo Carriageway, Ondo State Southwest Nigeria: Using Multiple Linear Regression", African Research Review, Vol 4, No. 2, pp 30-49, 2010.

[20] J.R. Aworemi, I.A. Abdul-Azeez and S.O. Olabode, "Analytical Study of the Causal Factors of Road Traffic Crashes in Southwestern Nigeria", Educational Research, Vol 1, No. 4, pp 118-124, 2010.

[21] O.A. Olushina and I.A. Mumini, "Multivariate Regression Techniques for Analyzing Auto-Crash Variables in Nigeria", Journal of Natural Sciences Research, Vol 1, No 1, pp 19-33, 2011.

[22] A.J. Aderamo, "Road Traffic Accident Injuries and Productivity in Nigeria", Journal of Asian Scientific Research, Vol 2, No 7, pp 334-344, 2012.

[23] A.O. Atubi, "Determinants of Road Traffic Accident Occurrences in Lagos State: Some Lessons for Nigeria", International Journal of Humanities and Social Science, Vol 2, pp 252-259, 2012.

[24] T. Isayomi, "Regional Determinants of Road Traffic Accidents in Nigeria: Identifying Risk Areas in Need of Intervention", African Geographical Review, pp 1-12.

[25] A.L. Ojo, "Predominant Causes of Road Traffic Accident among Commercial Vehicle Drivers in Ekiti State, Nigeria", The International Journal of Humanities and Social Studies, Vol 2, pp 1-5, 2014.

[26] M.O. Olawole, "Impact of Weather on Road Traffic Accidents in Ondo State, Nigeria: 2005-2012", Analele Universitatii din Oradea, Seria Geografie, Vol 1, pp 44-53, 2016.

[27] O.O. Aderinlewo and A. Afolayan, "Development of Road Accident Prediction Models for Akure-Owo Highway, Ondo State", Journal of Engineering Science, Vol 15, No. 2, pp 53-70, 2019.

[28] O. Aderinola, "A Parametric Model for Accident Prediction Along Ado Ekiti – Ikole Ekiti Road, Ekiti State, Nigeria", European Journal of Engineering and Technology Research, Vol 5, No. 8, pp 980-985, 2020.

[29] S.P. Miaou and H. Lum, "Modelling Vehicle Accidents and Highway Geometric Design

Relationships", Accidents Analysis and Prevention, Vol 25, No. 6, pp 689-709, 1993.

[30] V. Shankar, F. Mannering and W. Barfield, "Effect of Roadway Geometrics and Environmental Factors on Rural Accident Frequencies", Accident Analysis and Prevention, 1995.

[31] S.P. Miaou, "The Relationship between Truck Accident and Geometric Design of Road Sections: Poisson versus Negative Binomial Regressions", Accident Analysis and Prevention, Vol 26, No. 4, pp 471-482, 1994.

[32] J.M. Hilbe, Negative Binomial Regression, Cambridge: Cambridge University Press

[33] A.C. Cameron and P.K. Trivedi, Regression Analysis of Count Data, New York: Cambridge Press, 2013.

[34] M.M. Imprialou, M. Quddus, D.E. Pitifield and D. Lord, "Re-visiting Crash Speed Relationships: A New Perspective in Crash Modelling", Accident Analysis and Prevention, Vol 86, pp 173-185, 2016.

[35] W. Consiglio, P. Driscoll, M. Witte and W.P. Berg, "Effect of Cellular Telephone Conversations and Other Potential Interface on Reaction Time in a Braking Response", Accident Analysis and Prevention, Vol 35, No. 4, pp 495-500, 2003.

[36] A. Haadi, Identification of Factors that Cause Severity of Road Accidents in Ghana: A Case Study of the Northern Region", International Journal of Applied Science and technology, Vol 4, No 3, pp 242-249, 2014.

[37] I. Edunyah, "Causes of Tyre Failure on Road Traffic Accidents: A Case Study of Takordi Township", International Journal of Scientific and Research Publications, Vol 6, No. 2, pp 30-35, 2016.

[38] S.D. Oduro, "Brake Failure and its Effect on Road Traffic Accidents in Kumasi Metropolis, Ghana", International Journal of Science and Technology, Vol 1, No. 9, pp 448-453, 2012.

[39] F.R. Moghaddam, Sh. Afandizadeh and M. Ziyadi, "Prediction of Accident Severity in Urban Highways", International Journal of Civil Engineering, Vol 9, No. 1, 41-49, 2011.

[40] T. Brigs, D. Karlis and G. Wets, "Studying the Effect of Weather Conditions on Daily Crash Count using a Discrete Time-Series Model", Accident Analysis and Prevention, Vol. 40, No. 3, pp 1180-1190, 2008.

[41] J. Xu., K.M. Kockerlman and Y. Wang, "Modeling Crash and Fatality Counts along Main Lanes and Frontage Roads across Texas: The Roles of Design, the Built Environment, and Weather", Presented at the 93rd Annual Meeting of Transportation Research Board, Washington D.C., USA, January 2016.

[42] T.A. Ogunmodede, G. Adio, A.S. Ebijuwa, S.O. Oyetola and J.O. Akinola, "Factors Influencing High Rate of Commercial Motorcycle Accidents in Nigeria, American International Journal of Contemporary Research, Vol 2, pp 130-140, 2012.

[43] J.M. Hilbe, Modeling Count Data, Cambridge: Cambridge University Press, 2014.