MODELLING AND FORECASTING OF ROAD TRAFFIC CRASH AND DEATH OCCURRENCES IN ANAMBRA STATE, NIGERIA

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ABSTRACT
This research work examined Road Traffic crashes and deaths in Anambra State, with specific objectives of determining the pattern of the crash and number of deaths involved, causative factors of the crashes and also forecast for expected road traffic crash for 2019-2028 in Anambra State, Nigeria. The data used for this study was collected from the report on Road Traffic crash (2006-2018) of the Federal Road Safety Corps (FRSC) Anambra State Command. The results from the analysis showed that there is a random and seasonal variation of road traffic crash in Anambra State over the years, with linear trend of $y_t = 11.70 + 0.1035t$ *in total crash cases and* $y_t = 3.904 + 0.007t$ *in fatal cases. The year 2015 was found to be the highest in number of deaths recorded as a result of traffic crash. Also, Onitsha and Nnewi units' commands were observed to be the highest recorded cases of traffic crashes. The results equally indicated that all the causative factors were significant on the accident with p=0.015* $< \alpha = 0.05$ *which falls on the rejection region of the hypothesis assuming 95% confidence level. More so, R-square (*R^2*) value of 0.931 (93.1%) from the analysis implied that the independent variables(accident causative factors) were able to explain 93.1% of the total variations in road traffic crashes in Anambra state for the periods under review indicating adequacy of the model in estimating accident .Furthermore, ten years predictions of the cases of road traffic crash were obtained using the ARIMA model with trend of* $y_t = 176.4 + 15.30t$ *showed that road traffic crash would continue be on increase with the period under reviewed . Recommendations were made based on the findings for legislation to strengthen Traffic existing laws and incorporate seizure of traffic offender's vehicle for gross misconduct and detention/suspension of such drivers. Also, training and orientation of drivers on road signs and rules before issuance of driving licenses should be adopted and introduction of bumps on major roads to limit speed should be prioritized.*

Key words; Road traffic crash, causative factors, deaths, FRSC, ARIMA Model and Multiple regression.

1. INTRODUCTION

Death and injuries resulting from road traffic accidents remain a serious problem globally and current trends suggest that this will continue to be the case in the foreseeable future WHO (1990). A report on current state of global road safety revealed that the number of road traffic death continues to climb, reaching a high of 1.35 million in 2018 (WHO, 2018). Road traffic injuries are the 8thleading cause of death for all age groups.The International Road Federation, Geneva Programme Center reported that approximately 2.4 million people have

died in road accidents across the world, with a yearly record of 1.3 deaths and daily record of 3,000 deaths. A study carried out by Chen show that the fatality rate in African countries ranges from 10-fold to more than 100-fold than in the United States. (Chen, 2010). Lagarde (2007) reported that Africa has an average rate of 28.3 per 100,000 population road traffic mortality compared within Europe. Despite integrated efforts towards reducing fatal road accidents, Nigeria still remains one of the worst hit countries with a human population of about 167 million with a high level of vehicular population estimated at over 7.6 million, a total road length of about 194,000 kilometers (comprising 34,120 km of federal, 30,500 km of state, and 129,580 km of local roads), the country has suffered severe losses to fatal car accidents. Its population density varies in rural and urban areas at about 51.7% and 48.3% respectively and translates to a population–road ratio of 860 persons per square kilometre, indicating intense traffic pressure on the available road network (Sumaila, and Agbonkhese, 2013). Anambra state, a heavily industrialized and commercial State with a network of interstate and intra-city roads has recorded road traffic accidents over the years and the figure continues to rise; however, studies on the current trends and causes of Road Traffic Accident in the state are limited (Iteke et al, 2011) . This study therefore, focused to determine the trend pattern, identify the major causes, make forecast as well as proffer solutions to road traffic crashes and deaths in Anambra State, South Eastern Nigeria for the periods under review.

2.0 Review of Related Literature

Nantulya (2002) noted that the morbidity and mortality burden in developing countries is rising due to a combination of factors, including rapid motorization, poor road and traffic infrastructure as well as the behavior of road users. Muhlrad and Lassarre (2005) emphasized that road traffic accidents (RTAs)and injuries are multiple dimensional problems that require a comprehensive view when examining determinants, consequences and solutions. Aderamo (2012) studied Spatial Pattern of Road Traffic Accident Casualties in Nigeria, the study made use of data from the Nigerian Police Force Headquarters and the Federal Road Safety Commission and the result showed that spatial variation exists in the incident of road traffic accident in Nigeria.

Ukoji (2014) carried a retrospective study on Trends and patterns of fatal road accidents in Nigeria from 2006 – 2014 .The findings from the study showed that the distribution of fatal car accidents among the 36 states and the FCT shows that Lagos State recorded the highest number of fatal car accidents but was less dangerous after calculating the severity index. Abuja is more dangerous when compared with its relative number of inhabitants. Results further showed that regional variations exist in the fatality rate of road accidents with more deaths occurring in the South than in the North. The results also established that state and city population estimates, number of registered vehicles and trade volume are among the variables that determine the fatality rate of road accidents in Nigeria. Oyenuga et al (2016) aimed at finding a suitable time series model to forecast the future characteristics of the road accident data on Oyo-Ibadan express road using the additive model approach and time plot plotted in the study showed a constant movement from 2004-2008 but increases abnormally in 2010 and later drop again maintaining appreciable downward movement as the year progresses. The Judgment from the result indicated that accidents and deaths are higher during the festive period months because of the various festivities lined up during this period, which involve much more traveling than usual.

Agbeboh and Osarumwense(2013) Looked at the trend of road accident in Kogi State from January 1997-December 2010 using a univariate time series data and model was found .The test for the existence of trend and seasonal variation were conducted as well as four years forecast made from 2012 -2015 and result of the analysis showed no seasonal variation but trend indicated steady increase in Kogi accident rate. Maina(2010) examined the causes of road traffic accidents along Abuja-Lokoja highway using a survey questionnaire and secondary data obtained from the Federal road safety corps (FRSC) Kogi State and Federal Capital Territory (FCT) sector commands for the period 2003 to 2012. The result of the analysis showed that human related factors are mainly responsible for majority of the accident in the study area. Similarly, cars and buses are vehicle types that are frequently involved in accident on the road. Also majority of the accidents on the road occur during the daytime especially from 6am to 6pm.

Greg (2010) carried out study of updates on the status, trends, causes, countermeasures and issues in traffic safety in African countries by reviewing studies published in the past 12 year. The study found that traffic fatalities continued its upward trend in recent years. Similar to those in motorized countries, the study also identified that human behavior and incapacitation account for more than 85% of the contributing factors reported by police in Africa. Unlike in developed countries, the victims of traffic casualties are primarily vulnerable road users.
Agbonkhese *et al*.(2013) and Adejugbagbe *et al*. (2015)recent studied conducted in different states in Nigeria showed that RTA still requires urgent attention to characterize and put in appropriate intervention from all quarters routine and timely evaluation of the RTA regarding trend, the probable causes, the types of vehicles involved in the accidents, whether they are commercial or private, the number of persons involved as well as the severity of accidents is a prerequisite for the development of measures aimed at reducing the RTA in Nigeria.

3.0 Materials and Methodology

Source of Data

Data were obtained from the Federal Road Safety Corps, Anambra State Command. Information extracted is secondary from 2006-2018 comprising sex, cause of accidents, and number of people cases recorded as fatal, serious and minor as well as deaths.

ARIMA MODEL

An ARIMA model is a class of statistical model for analyzing and forecasting time series data. ARIMA is an acronym that stands for **A**uto **R**egressive **I**ntegrated **M**oving **A**verage. It is a generalization of the simpler Auto Regressive Moving Average and adds the notion of integration. This acronym is descriptive, capturing the key aspects of the model itself. Briefly, they are:

a) **AR**: Auto regression. A model that uses the dependent relationship between an observation and some number of lagged observations.

b) **I**: Integrated. The use of differencing of raw observations (i.e. subtracting an observation from an observation at the previous time step) in order to make the time series stationary.

c) **MA**: Moving Average. A model that uses the dependency between an observation and residual errors from a moving average model applied to lagged observations.

Each of these components is explicitly specified in the model as a parameter. A standard notation is used of ARIMA (p, d, q) where the parameters are substituted with

Integer values to quickly indicate the specificARIMA model being used.
The parameters of the ARIMA model are defined as follows:
i) **p**: The number of lag observations included in the model, also called the lag order.
ii) d: The number of times that the raw observations are differenced, also called the degree of differencing.
iii) **q**: The size of the moving average window, also called the order of moving average

Multiple Regression
The Multiple regression model is used in this study to model the causative factors of Road Traffic crashes/ Accidents in Anambra State, Nigeria.
Multiple regression is a statistical technique that uses several explanatory variables to predict the outcome of a response variable. The goal of multiple regression is to model the linear relationship between the explanatory (independent) variables and response (dependent) variable

Multiple regression (MR) is used to determine a mathematical relationship among a number of random variables. In other terms, MR examines how multiple independent variables are related to one dependent variable. Once each of the independent factors has been determined to predict the dependent variable, the information on the multiple variables can be used to create an accurate prediction on the level of effect they have on the outcome variable.

Multiple Regression Model is given as

$$y_i = \beta_0 + \beta_1 x_{i1} + \ldots + \beta_q x_{iq} + \varepsilon_i$$

Where
Y is the Outcome Variable
$\beta_0, \beta_1, \ldots, \beta_n$ are the parameters of the model
$x_1, x_2, \ldots, x_n$ are the predictors

DATA PRESENTATION
Table 3. 1 Summary of Road Traffic Crashes in Anambra State for the periods (2006-2018)

Months	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Jan	9	5	9	8	10	11	14	4	19	26	16	21	20
Feb	7	15	13	6	6	4	18	75	20	12	14	21	14
Mar	10	13	11	7	11	15	16	56	13	26	22	22	21
Apr	8	16	11	10	7	16	28	128	21	27	12	21	15
May	13	19	15	9	10	4	19	82	32	19	21	21	25
Jun	7	15	15	14	4	9	31	39	31	20	10	29	13
Jul	15	25	13	9	9	9	37	43	24	20	24	22	37
Aug	13	16	13	14	12	5	40	79	21	14	25	21	32

Sept	13	20	8	10	5	12	30	31	18	19	20	39	49
Oct	9	13	13	5	6	9	19	48	24	20	15	47	36
Nov	16	15	16	3	15	7	21	72	25	8	24	33	42
Dec	15	18	19	11	8	10	32	85	42	18	22	52	56
Total													

Source: FRSC records

Table 3. 2 summary of Road traffic Cases and Deaths in Anambra State

Years	Fatal cases	Serious cases	Minor cases	Deaths		
				Female	Male	Total
2006	51	34	50	22	44	66
2007	63	60	67	40	83	123
2008	54	58	44	26	14	40
2009	35	43	28	33	39	72
2010	35	44	24	28	28	56
2011	27	42	37	22	45	67
2012	67	178	61	20	47	67
2013	50	147	45	18	58	76
2014	82	159	32	21	99	120
2015	75	135	19	39	135	174
2016	50	126	45	17	56	73
2017	32	109	55	13	37	50
2018	100	220	20	43	57	100

Source: FRSC records

Table 3.3 Road Traffic Crashes Causative Factors in Anambra State(2006-2018)

YEARS	**MECHANICAL FAULT**	**SPEED LIMIT VIOLATION**	**OVER LOADING**	**USE OF PHONE WHILE DRIVING**	**TYRE BURST**	**LOSS OF CONTROL**	**DANGEROUS OVERTAKE**	**BAD ROAD**	**SLEEPING ON STEERING**	**ROAD OBSTRUCTION VIOLATION**	**SIGN LIGHT VIOLATION**

2006	14	94	4	1	5	26	15	4	1	0	2
2007	5	43	6	1	11	63	6	0	0	1	1
2008	13	103	6	0	13	74	13	1	1	0	1
2009	19	92	4	0	10	45	7	0	0	1	0
2010	15	82	2	4	15	64	27	10	5	2	11
2011	3	113	1	2	12	39	16	3	2	2	2
2012	6	64	1	0	17	103	8	0	0	0	9
2013	3	90	0	3	18	56	23	3	0	1	3
2014	4	113	2	1	13	62	12	2	0	0	3
2015	7	86	2	3	5	46	9	0	1	1	2
2016	12	74	2	2	18	49	11	1	4	0	0
2017	0	111	2	1	11	50	6	1	3	0	4
2018	17	59	7	0	22	74	4	0	0	0	1

Source: FRSC records

4.0 RESULTS OF THE DATA ANALYSIS

4.1 Time Series Analysis

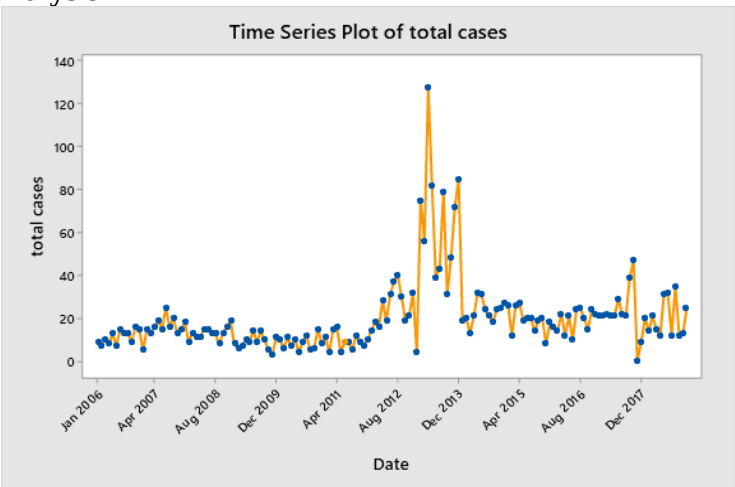

Fig4. 1: Graph of Time plot on total crash cases

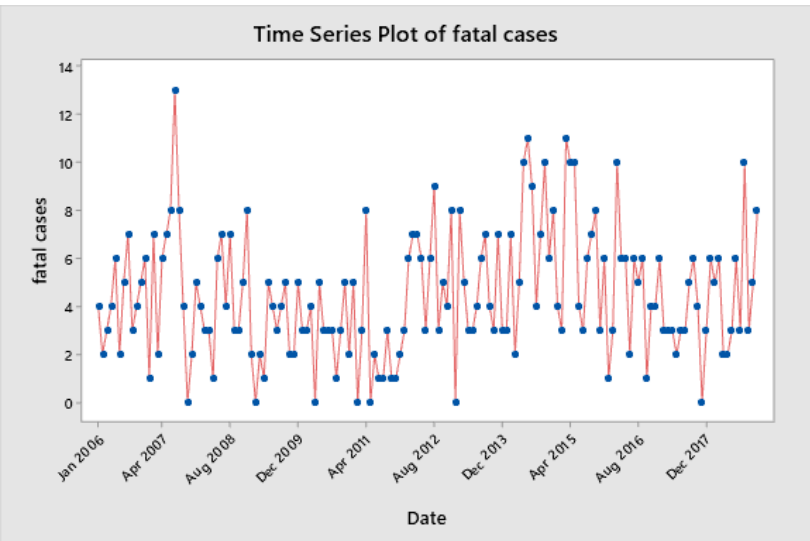

Fig4. 2: Graph of Time plot on fatal crash cases

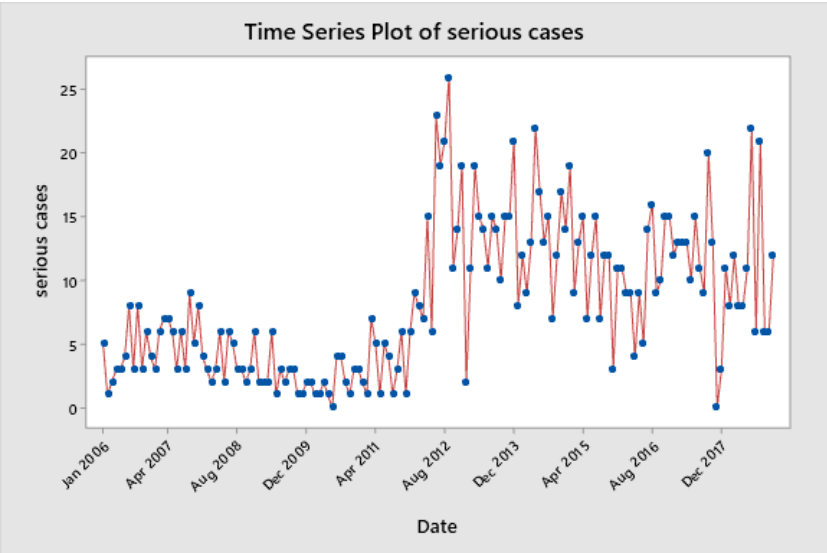

Fig 4. 3: Graph of Time plot on serious crash cases

Figures 4. 1, 4. 2 and 4. 3 shows the time plots of the total cases, the fatal cases and the serious cases of road traffic crashes in Anambra State from 2006-2018. We observed from the series that we have both trend and seasonality. That is, there is upward movement and downward movement of the trend.

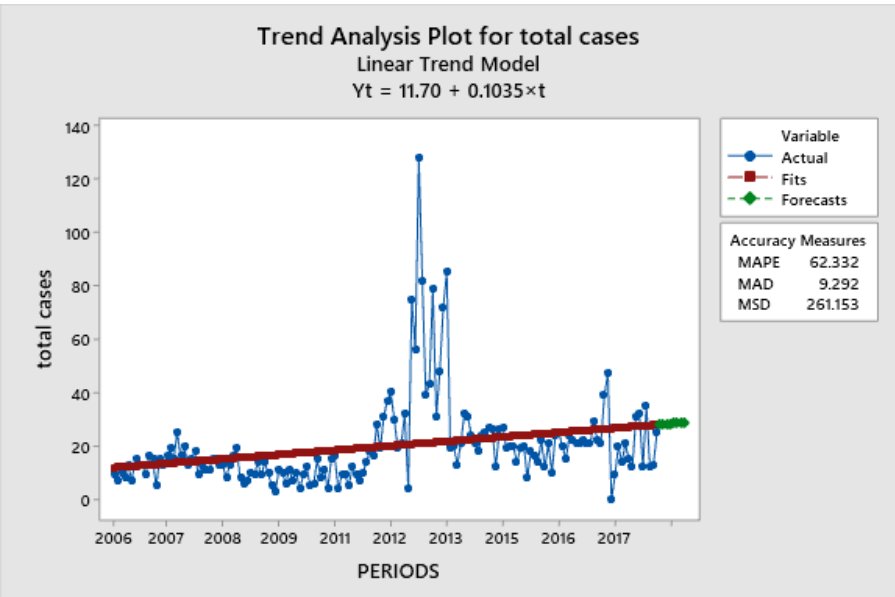

Fig 4.4: Graph of trend plot of Total crash cases

Figure 4.4 above measures the changes in number of total crash cases over time. The trend analysis showed fluctuations in the trend of the total crash over time. In comparing the number of crashes over the years of the study, it was shown that the highest crash occurred in 2012 with total number of 130 cases where as the lowest crash occurred in 2006 with total number of 20 cases.

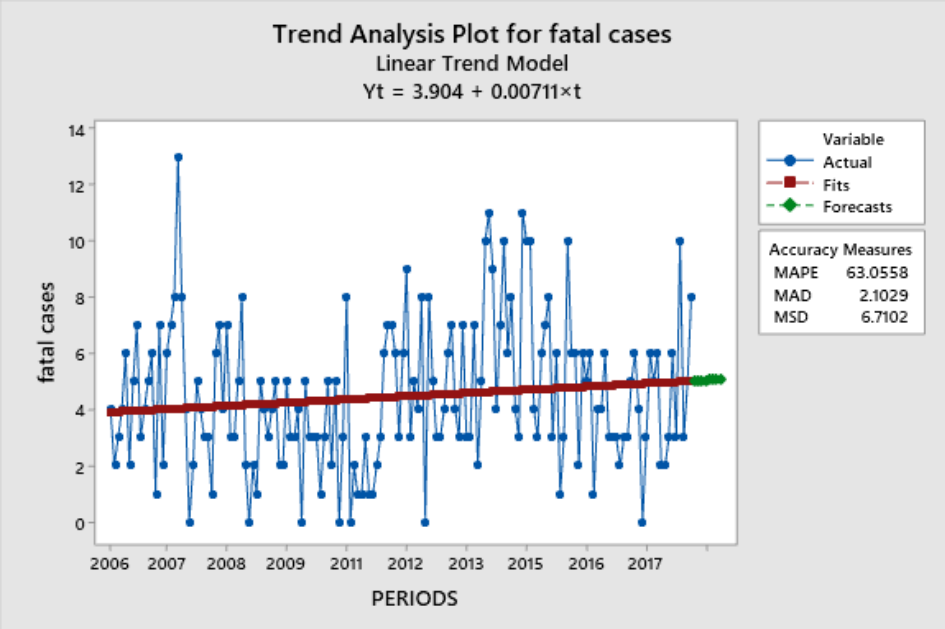

Fig 4. 5: Graph of trend plot of fatal crash cases

In Figure 4.5 of the graph of all fatal cases over time for the period of study review there is a seasonal variation in the trend as we noticed that some of the years are high while others are low. Year 2007 were observed to have the highest occurrence in number of fatal crash cases with total fatal crash cases of 13 occurring in a single month with fitted trend line of Yt = 3.904 + 0.00711×t

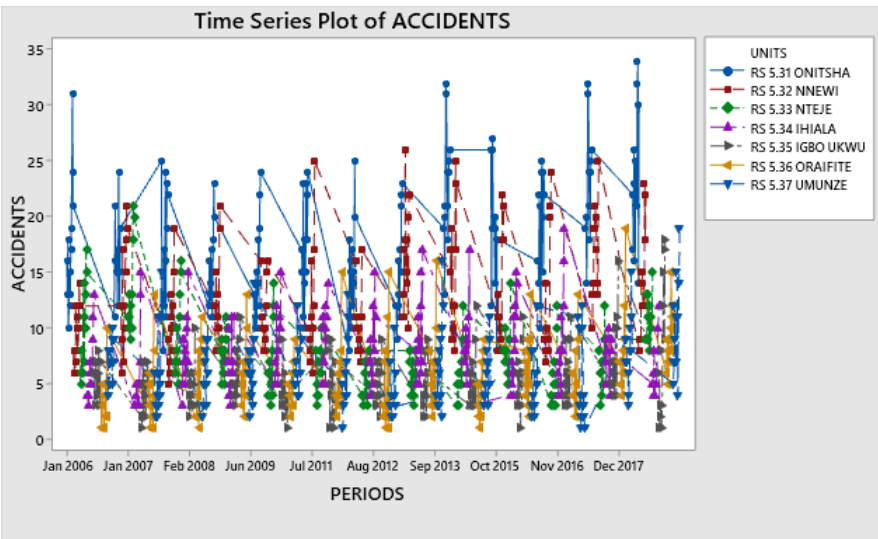

Fig 4. 6: Graph of Crash cases by unit command

Variable	UNITS	Total Count	Mean
ACCIDENTS	RS 5.31 ONITSHA	156	18.122
	RS 5.32 NNEWI	156	12.808
	RS 5.33 NTEJE	156	7.718
	RS 5.34 IHIALA	156	7.917
	RS 5.35 IGBO – UKWU	156	5.487
	RS 5.36 ORAIFITE	156	5.654
	RS 5.37 UMUNZE	156	6.397

The figure and table above asssessed crash cases by the unit commands in the state in order to determine the route with highest observed cases of crash over the period of study. from the figure the month of December was observed to be the highest in the occurrence of crashes in Onitsha unit command having the highest load in number of crash with a mean of 18.122. This can be attributed to the fact that Onitsha is the commcerical city in the state with high rate of vehicular movement. Nnewi was next in number of crash occurrence with mean 12.808 crashes.

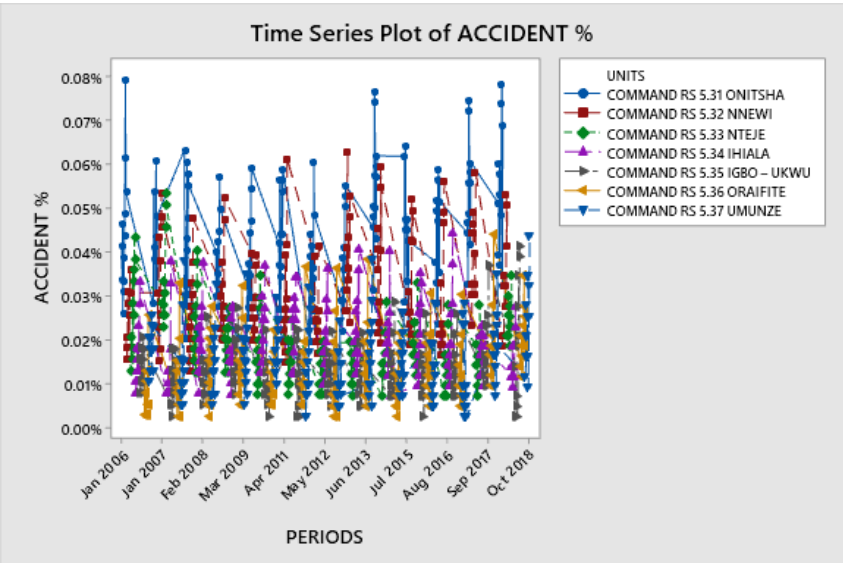

Fig4. 7: Graph of crash rate of occurrence by Unit Command

Figure 4. 7 showed the rate of crash occurrence in each unit within the year under study. The rate was measured as a percentage. Year 2006 was observed to be the year with highest rate of occurrence.

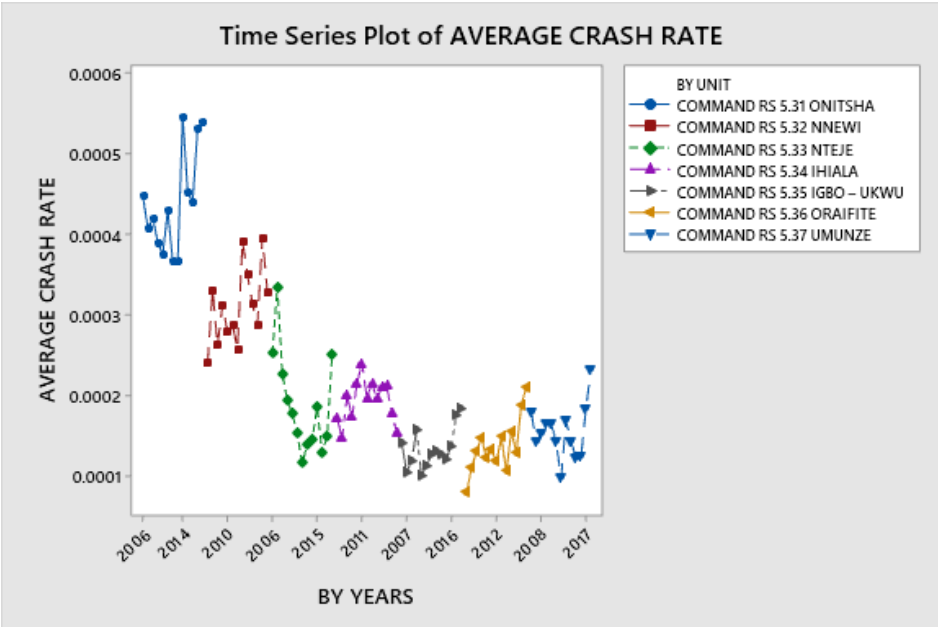

Fig 4. 8: Graph of average crash rate

Figure 4. 8 measures average crash rate by each unit command. From the figure Onitsha unit command was observed to be highest in average crash cases for the periods of study.

4.2 Multiple Regression Analysis

Multiple regression analysis was carried out to determine the relationship that exists between traffic crashes and their causative factors. Traffic crash cases was the dependent variable while causative factors were the independent variables

The Hypothesis

H_0 : **All the causative factors are significant**

H_1 : **At least one factor is different**

Table 4.1 Model Summary[b] of multiple regression analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.965[a]	.931	.169	151.87255

a. Predictors: (Constant), SIGN_LIGHT_VIOLATION, SPEED_LIMIT_VIOLATION, ROAD_OBSTRUCTION_VIOLATION, MECHANICAL, TYRE_BURST, SLEEPING_ON_STEERING, DANGEROUS_OVERTAKEN, OVERLOADING, LOSS_OF_CONTROL, USE_OF_PHONE, BAD_ROAD

b. Dependent Variable: ACCIDENTS

Source: from computation

The table 4.1 shows the multiple linear regression model summary and overall fit statistics. We find that the adjusted R^2 of our model is .169 with the R^2 = .931. This means that the linear regression explains 93.1% of the variance in the data. The correlation coefficient

R=.965 indicates that there is a strong positive linear relationship between the predicators (causative factors) and the dependent variable (traffic Crash).

Table 4.2 ANOVA[a] test of significance

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	310087.807	11	28189.801	1.222	.015[b]
	Residual	23065.270	1	23065.270		
	Total	333153.077	12			

a. Dependent Variable: ACCIDENTS
b. Predictors: (Constant), SIGN_LIGHT_VIOLATION, SPEED_LIMIT_VIOLATION, ROAD_OBSTRUCTION_VIOLATION, MECHANICAL, TYRE_BURST, SLEEPING_ON_STEERING, DANGEROUS_OVERTAKEN, OVERLOADING, LOSS_OF_CONTROL, USE_OF_PHONE, BAD_ROAD

Source: from computation

In table 4.2, the linear regression's F-test has the null hypothesis that the model explains zero variance in the dependent variable (in other words $R^2 = 0$). This implied that F-test is highly significant, thus we can conclude that the model explains a significant amount of the variance in traffic crash rate. Multiple linear regression analysis indicated highly significant causative factor coefficients except speed limit violation.

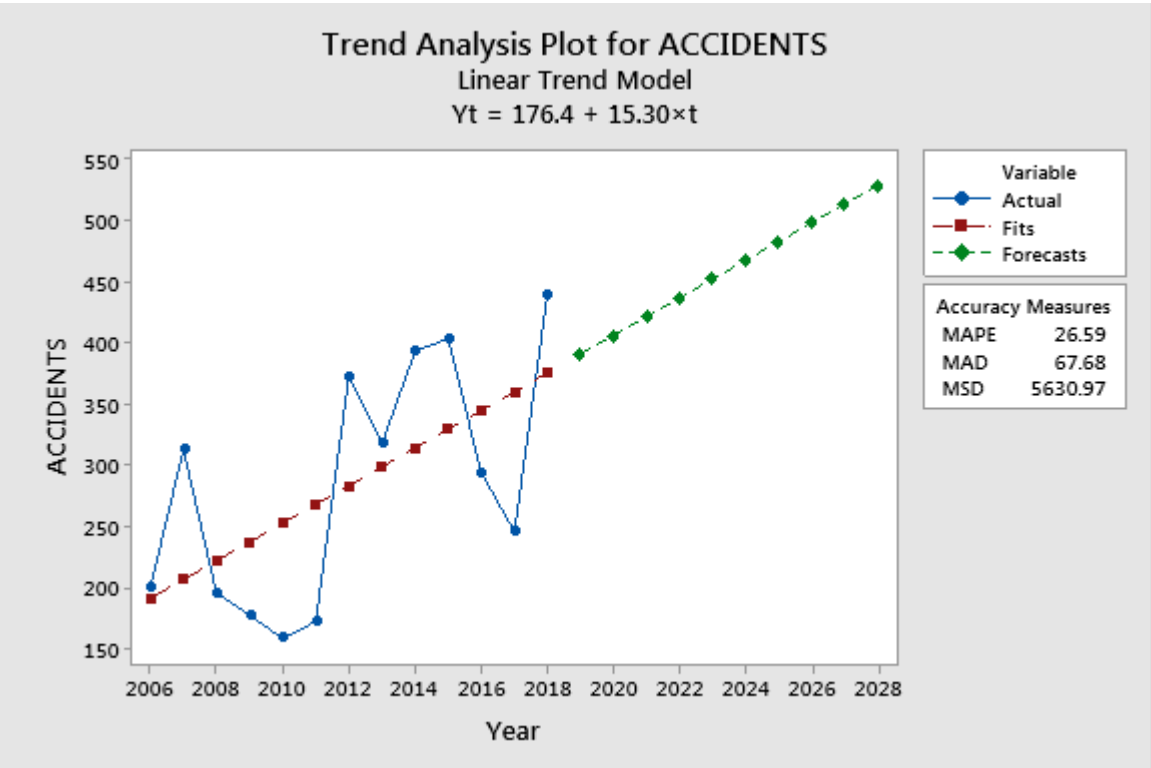

Fig 4.9: Graph of forecast of traffic crashes/accidents

Table 4.3: Result of Forecast for the period of ten years

Period	Forecast
2019	390.654
2020	405.956
2021	421.258
2022	436.560
2023	451.863
2024	467.165
2025	482.467
2026	497.769
2027	513.071
2028	528.374

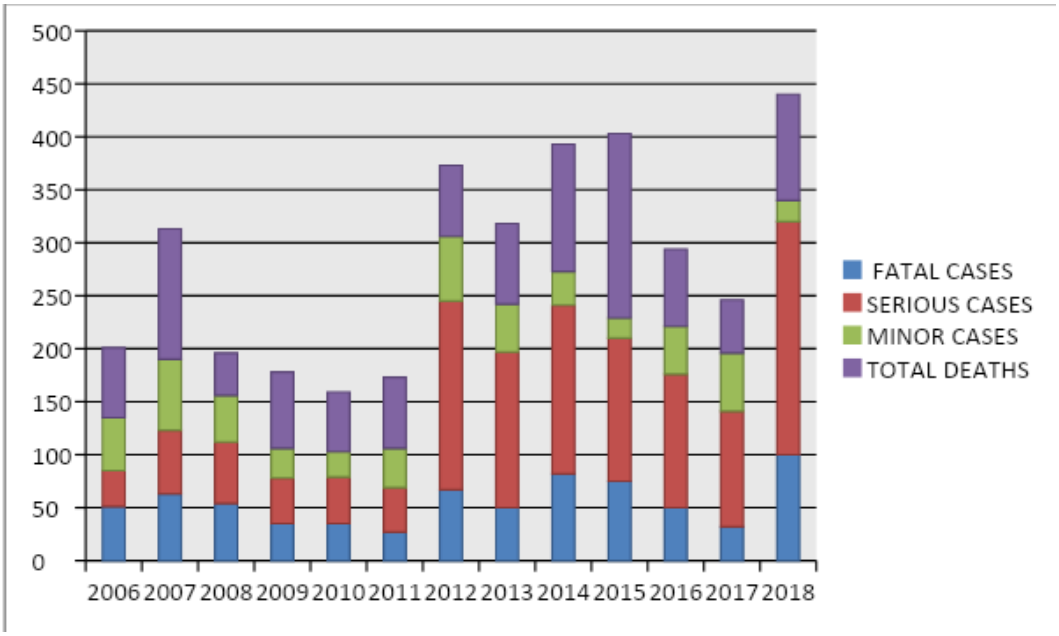

Figure 4.10: Descriptive chart of Road Traffic crash/ accident and death cases

5.0 Summary of the Findings

Our review of the trends of Road Traffic crashes in Anambra State from January 2006-December 2018 revealed a consistent increase in the number of road crashes, injuries as well as deaths. The number of people involved as well as the number of vehicles involved with a noticeable spike in 2013 and a gradual decline in 2015 is occasioned by the massive relocation of displaced persons from the northern part of the country to the south east due to the insecurity in the north prompted by the insurgency. Our finding is similar to findings from a study conducted in Abuja by Ukoji *et al*., in 2014. They found that an upsurge in the human and vehicular movement has resulted in more fatal road traffic accidents. The steady decline observed from 2014 could be adduced to return to normalcy and less vehicular and human movement. Onitsha and Nnewi Unit command were observed to have high rate of occurrence in Road traffic crash within the years under study. The reason can be attributed to

the fact that both cities are the major commercial cities in Anambra state and they witness heavy vehicular movements'human factors (speed limit violation, loss of vehicle control and dangerous overtaking) were the leading causes of road traffic crashes/ accidents from 2010-2014. This finding is similar to previous study conducted on Road Traffic Accident in Ibadan, Nigeria by Adejugbagbe *et al*. The finding further supports the WHO Global status report on road safety, 2018 which reported that leading causes of road traffic accidents are both predictable and preventable and that changing user behavior is a critical component of the holistic "safe systems" approach.

5.1 Conclusion

It has been established that Road Traffic crash are still claiming lives and properties all over the world, and leading to adverse social and economic cost in countries. From the analysis, trend is used to find out whether road crash/ accident is increasing or decreasing and it shows that there is an increase in road accidents over the course of the years in each quarter. These increments, traceable to human factors are due to over speeding, dangerous driving, tyre burst, brake failure, stationary vehicle /obstruction, drinking and driving, poor weather, mechanical deficiency etc. The findings from our study have further shown that road traffic crashes remain a growing pandemic so there is need for repair and reconstruction of bad roads, legislation to strengthen traffic existing laws and incorporate seizure of traffic offender's vehicle for gross misconduct and detention/suspension of such drivers. Also, training and orientation of drivers on road signs and rules before issuance of driving licenses should be adopted and introduction of bumps on major roads to limit speed should be prioritized.

REFERENCES

[1] Aderemo, A.J (2012).Spatial Pattern of Road Traffic Accident Casualties in Nigeria. Mediterranean Journal of Social Sciences.

[2] Adejugbagbe,A.M,Fatiregun A.A, Ambrose R and Alonge T.(2015).Epidemiology of road traffic crashes among long distance drivers in Ibadan, Nigeria. Journal of African Health Sciences vol. 15 issue2, June 2015.Do1://dx.doi.org/10.4314/ahs.vi512.22.

[3] Agbeboh G. U. and Osabuohien-IraborOsarumwense(2013) Empirical analysis of road traffic accidents: A case study of Kogi State, North-Central Nigeria Vol. 8(40), pp. 1923-1933, 30 October, 2013 DOI: 10.5897/IJPS2013.3978 ISSN 1992 - 1950 © 2013

[4] Agbonkhese, O, Yisa, G.L, Agbonkhese, E.G, Akanbi, D.O, Aka, E.O, Mondigha, E.B (2013), Road Traffic Accidents in Nigeria: Causes and Preventive Measures. Civil and Environmental Research, ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online), Vol.3, No.13.

[5] Chen, G. (2010). Road Traffic Safety in African Countries – Status, Trend, Contributing Factors, Counter Measures And Challenges, International Journal of Injury Control and Safety Promotion, 17(4): 247 – 255.

[6] Greg Chen(2011).Road traffic safety in African countries – status, trend, contributing factors countermeasures and challenges International Journal of Injury Control anSafet Promotion, Volume 17, 2010 - Issue 4**Published Online:** 08 Jun 2011

[7] Iteke O, Bakare MO, Agomoh AO, Uwakwe R, Onwukwe JU.(2011). Road traffic accidents and posttraumatic stress disorder in an orthopedic setting in South-Eastern Nigeria: a controlledstudy. Scand J Trauma ResuscEmerg Med. 2011;19:39. [PMC free article] [PubMed] [Google Scholar

[8] Lagarde, Emmanuel (2007), Road Traffic Injury Is an Escalating Burden in Africa and DeservesProportionate Research Efforts, PLoS Medicine, vol.4, n°6, pp.967-71

[9] MAINA Williams Esther(2010) ANALYSIS OF ROAD TRAFFIC CRASH ALONG LOKOJA – ABUJA HIGHWAY, NIGERIA

http://kubanni.abu.edu.ng/jspui/bitstream/123456789/8509 assessed June 10, 2019

[10] Muhlrad N and S. Lassarre (2005) 'Systems approach to injury control' in Tiwari G, D. Mohan,N, Muhlrad (eds) 'The way forward: transportation planning and road safety'. New Delhi,Macmillan India Ltd.

[11] Nantulya, V.M (2002) 'Equity Dimensions of Road Traffic Injuries in low and middle-incomecountries'.Havard Centre for Population and Development Studies, Cambridge. USA. Available at: http://www.bmj.com/content/324/7346/1139.full.pdf+html [Accessed on 25/6/2019]

[12] OyenugaIyabodeFavour, Ayoola Femi Joshua, ShittuOlanrewaju Ismail (2016) Statistical Analysis of Pattern on Monthly Reported Road Accidents in Nigeria, Science Journal of Applied Mathematics and Statistics. Vol. 4, No. 4, 2016, pp. 119-128. doi: 10.11648/j.sjams.20160404.11

[13] Sumaila, Abdul and Ganiyu Femi (2013). Road crashes trends and safety management in Nigeria,Department of Transport Management Technology, Federal University of Technology, Minna

[14] UKOJI Vitus Nwankwo (2014) Trends and patterns of fatal road accidents in Nigeria (2006-2014)IFRANigeriaworkingpapersseries,n°3528/11/2014http://nigeriawatch.org/media/html/WP6VitusV6Final.pdf.

[15] WHO (1990) A Public Health Perspective of Road Traffic Accidents

[16] WHO (2018) Global Status Report on Road Safety (2018) Geneva: World Health Organization; 2018. Licence: CC BY-NC-SA 3.0 IGO.