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Statistical Modelling of Road Traffic Accidents: Pattern and Trend in Kogi State, Nigeria

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Abstract. Road traffic accident (RTA) is defined as unplanned car crash that causes injuries, fatalities, and property damage. In order to better understand the pattern and trend of road traffic accident in Kogi state, Nigeria, we statistically modeled RTA data collected from Federal Road Safety Corps, Lokoja from January 2017 to December 2021. The data consisted of monthly RTA types and outcomes. The RTA types considered were fatal, serious and minor while the RTA outcomes were death, injury and no injury. Time series modeling was adopted for modeling and predicting the accident rates while Pearson correlation was used to determine the degree of relationship between RTA types and outcomes. Results showed that there were steady fluctuations in the patterns of RTA types and outcomes between February and October while there were upward trend in RTA from November to January. The augmented Dickey-Fuller test showed that RTA series was stationary and out of 10 candidate models obtained using ACF and PACF plots, the best model suitable for forecasting RTA rate was found to be ARIMA(1,0,1) using mean absolute deviation (MAD) and mean square error (MSE) selection criteria. In order to estimate the parameters of the model, the Shapiro-Wilk test was conducted on the RTA values and its residuals to confirm normality. Since $p < 0.05$ in both cases, they were both found to be non-normal, then the least absolute deviation (LAD) estimator was used for estimation. This gives rise to $Y_t = 29.0574 + 0.492151X_{t-1} + 0.99994e_{t-1} + \varepsilon_t$ as the best fitted model, which was found to be statistically significant at $\alpha=0.05$. The estimated model was used to forecast RTA for 30months with 95percent confidence level and result showed that the forecast were good and there will continually be occurrence of RTA nearly every month and there will be higher RTA rates between November and January. The result of the Pearson correlation showed that fatal accident were 71percent more likely associated to death while serious accident were 61percent more likely associated to injury.

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Key words and phrases. road traffic accident (RTA); stationarity; augmented Dickey-Fuller (ADF); least absolute deviations (LAD); Shapiro-Wilk; time series modelling; forecasting; Pearson correlation.

1. INTRODUCTION

Road traffic accident or crash refers to an unplanned event leading to personal injury, loss of lives or damage to property that has taken place in an area intended for public transport or generally used for transport and in which at least one of the involved parties has been a moving vehicle. Also, traffic accident or crash occurs when a vehicle collides with another vehicle, pedestrian, animal, road barriers, or any stationary obstruction such as a tree or a utility pole. Traffic collisions may result in injury, death, vehicle and possession damage (Mohammed et al., 2019). Traffic accidents cause many losses especially of human life, properties, and other resources. It claims the largest toll of human life and tends to be the most serious problem all over the world (Osoro, Ng'ang'a and Yitambe, 2015). Public health experts worldwide concede that there is a global epidemic of road traffic accidents (RTA) and globally, road traffic accident is the leading cause of injury-related deaths (Onyemaechi and Ofoma, 2016).

According to World Health Organization report of 2018, every year the lives of approximately 1.35 million people are cut short as a result of road traffic crash across the world. Between 20 and 50 million more people suffer non-fatal injuries, with many incurring a disability as a result of their injury. It causes considerable economic losses to individuals, their families, and to their nations. These losses arise from the cost of treatment as well as lost productivity for those killed or disabled by their injuries and for family members who need to take time off work or school to care for the injured (WHO, 2018). Road traffic crashes cost most countries 3% of their gross domestic product. More than 90% of road traffic deaths occur in low- and middle-income countries, road traffic injury and death rates are highest in the African region and lowest in the European region. Even within high-income countries, people from lower socioeconomic backgrounds are more likely to be involved in road traffic crashes. Road traffic crash is the leading cause of death for children and young adults aged 5-29 years. Approximately three quarters (73%) of all road traffic deaths occur among young males under the age of 25 years, who are almost 3 times as likely to be killed in a road traffic crash as young females, implying that young males are more likely to be involved in road traffic crashes than females. WHO's global report of 2018 attributed the risk factors of road traffic accident deaths to over-speeding, unsafe road infrastructure, distracted driving, driving under the influence of alcohol and other psychosocial drugs, unsafe vehicle, lack of proper enforcement of road safety laws, lack of use of motorcycle helmet, seat-belts and child restraint as well as inadequate post-accident care.

The World Health Organization reported that more than half of all road traffic deaths involve vulnerable road users such as pedestrians, cyclists and motorcyclists as well as their passengers. Also, road traffic accidents death has reached 41,693 or 2.82% of total deaths in Nigeria, whilst road traffic accidents rank 9th in order of disease burden and are projected to be ranked 3rd in the future (WHO, 2022). In Nigeria, injuries and deaths resulting from RTA are on the rise and are Nigeria's third-leading cause of overall deaths, the leading cause of trauma-related deaths and the most common cause of disability (Onyemaechi and Ofoma, 2016). Nearly three-quarters of deaths resulting from motor vehicle crashes occur in developing countries and this problem appears to be increasing rapidly in these countries (Jacobs et al., 2000). Road traffic accidents are said to be the leading cause of death and hence human productivity loss worldwide (Chaudhry and Iqbal, 2018). The socio-economic costs of road traffic accident in Nigeria are immense and the direct cost of traffic casualties can perhaps, at best be understood in terms of huge labour loss, as it has been documented that persons injured in accidents on Nigerian highways no longer participate in the economic mainstream which amounts to a huge loss of labour to the nation's economy.

Apart from the huge economic and socio-economic losses to road traffic accidents injuries and deaths, the cost to society is immense, as loss of able bodied men and women who would have been involved in productive economic activities, loss of intellectuals in our schools, loss of resources to government and families and insurance companies, damage to properties are inestimable while its psychosocial impact on victims is traumatic. Suffering resulting from injuries and loss of life associated with road traffic accident is difficult to assign monetary value (Onakonaiya, 1991). Most times people with injuries often suffer physical pain and emotional anguish that is beyond any economic compensation. In some cases, permanent disability such as paraplegia (paralysis of the lower half of the body), quadriplegia (paralysis of all four limbs), and inherent loss of ability to achieve minor goals may lead to dependence on other people for economic support and routine physical care for the rest of the victim's life (Jacob, Aeron-Thomas & Astrop, 2000). Although, alcohol is generally thought to be the most common risk factor among all drugs, some evidence have also linked the use of minor tranquilizers such as benzodiazepines to increase risk of crash involvement (Gururaj, 2004). Again, there is evidence that drivers with diabetes, epilepsy, cardiovascular disease or mental illness experience higher crash and violation rates (Mishra et al., 2017) but there are also studies indicating that neither chronic medical conditions nor disabilities among automobile drivers put them at greater risk of road traffic accidents (Mohan, 2002).

As in other developing countries, road traffic accidents in Nigeria are one of the most serious problems in need of pragmatic solution. Yet this problem has been difficult to address probably because of the country's level of development. Nigeria is said to have the highest road traffic accident rates in Africa and the second in the world (Atubi 2013). According to one study, the proportion of deaths from road traffic accidents in Nigeria increased from 38.2 percent to 60.2 percent in the ten years from 1991 to 2001 (Obinna, 2007). Thus, Nigeria's annual 8,000 to 10,000 accident deaths between 1980 and 2003 were a major personal and traffic safety problem as well as a terrible waste of human resources for the country. In terms of the personal safety problem, Nigeria and indeed

Lagos State is a high risk region with an average of 32 traffic deaths per 1,000 people (Filani & Gbadamosi, 2007). This is very high compared with the United States' 1.6 traffic deaths per 1,000 populations and with the United Kingdom's 1.4 deaths per 1,000 people (Trinca et al., 1988). In terms of traffic safety, there are on average 23 accidents per 1,000 vehicles in Nigeria (i.e. 230 per 10,000 vehicles) far in excess of the accident rates in the USA (2.7 accidents per 10,000 vehicles) and the UK (3.2 accidents per 10,000 vehicles).

Also, according to data from the Nigerian Federal Road Safety Commission, the country has the highest rate of death from motor accidents in Africa; leading 43 other nations in the number of deaths per 10,000 vehicles crashes. Nigeria is followed by Ethiopia, Malawi and Ghana with 219,183 and 178 deaths per 10,000 vehicles respectively. Road traffic accidents' statistics in Nigeria reveal a serious and growing problem with absolute fatality rate and casualty figure rising rapidly. In majority of developing countries, accident occurrence and related deaths are relative to either population or number of vehicles. Ironically, in Nigeria, studies have indicated that better facilities in terms of good quality and standardized roads have been accompanied by increasing number of accidents. This is totally contrary to the trends in countries where even the level of sophisticated road network and volume of vehicular traffic are much higher. The rising figure of accident in Nigeria leads to the consideration, analysis and prediction of road traffic accident in Kogi state. The state was chosen due to its strategic location, being the confluence state with road networks connecting the Northern, Southern and Eastern parts of Nigeria. This study will however examine the pattern of road traffic accidents, existing road traffic rates as well as relationship between accident types and accident outcomes without leaving out prediction of future rates.

2. MATERIALS AND METHODS

Data Collection

The data used in this work was a secondary data collected from the Federal Road Safety Corps office, Lokoja Division, Kogi state. The data is a time series data consisting of recorded monthly road traffic accidents for a five (5) year period from January 2017 to December 2021. The data is therefore a time series data with a sample size of 60 (sixty). The data also consists of road traffic accident types and outcomes. The accident types were minor, serious and fatal while the outcomes were no injuries, injuries and fatalities (deaths).

Method of Data Analysis

Analysis of rates, trends, prevalence and patterns of road traffic accidents had been carried out using numerous approaches (Ohakwe, Iwueze and Chikezie, 2011; Agbeboh & Osbuohien-Irabor, 2013; Ukoji, 2014; Konlan et al., 2020) while the analysis of causes of road traffic accident death had also been reported (Tulu, Washington & King, 2007; Agbeboh & Osbuohien-Irabor, 2013). Statistical Modeling of road traffic accidents using Poisson regression model has also been reported (Famoye, Wulu & Singh, 2004; Nwankwo & Nwaigwe, 2015; Odukoya & Olubiyi, 2020). In this study, modeling of road traffic accident was considered using Autoregressive Integrated Moving Average (ARIMA) modeling, a time series technique widely used for prediction (Perone, 2020; Box et al., 2015). The aim of the study is to examine the pattern of accident in the state, trend of accident in the state as well and predicting future accident rates. This study also investigated the relationship between accident types and outcomes using correlation analysis. The analysis was carried out using STATA (version 17.0).

ARIMA Modelling

The autoregressive model of order p and the moving average model of order q are respectively

$Y_t = \beta_0 e_{t-1} + \beta_2 e_{t-2} + \cdots + \beta_q e_{t-q} = \sum_{\ell=0}^{q} \beta_\ell \, e_{t-\ell} + \varepsilon_t$ (1)

$Y_t = \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \cdots + \alpha_p Y_{t-p} = \sum_{\ell=1}^{p} \alpha_\ell \, Y_{t-\ell} + \varepsilon_t$, provided $-1 < \phi < 1$ (2)

A mixture of (1) and (2) developed in Box and Jenkins (1970) and denoted by ARMA (p,q) is given by

$Y_t = \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \cdots + \alpha_p Y_{t-p} + \beta_1 e_{t-1} + \beta_2 e_{t-2} + \cdots + \beta_q e_{t-q} + \varepsilon_t$ (3)

where ε_t is called white noise, with $E(\varepsilon_t) = 0 \; and \; V(\varepsilon_t) = \sigma^2$. It is obvious that by setting $p = 0$ (or $\phi_\ell = 0$, for all ℓ), (5) reduces to the MA *(q)* model, whereas by setting $q = 0$ (or $\theta_\ell = 0$, for all ℓ), it reduces to the AR*(p)* model. ARMA is appropriate when a system is a function of a series of unobserved shocks (MA) and its own behaviour (AR).

In a bit to gain some information about the nature of the data, the Augmented Dickey-Fuller (ADF) test was employed. The test is based on estimating the test regression of the form

$Y_t = \beta' D_t + \phi Y_{t-1} + \sum_{\ell=1}^{p} \alpha_j \Delta Y_{t-j} + \varepsilon_t$ (4)

3. ANALYSIS

The analysis of the road traffic accident (RTA) data was carried out using descriptive and inferential statistics. The descriptive part involves the use of time plot while the inferential part employed autoregressive moving average (ARIMA) modeling and correlation analysis. Time plots were constructed to understand the underlying phenomenon and patterns of the data. A test of stationarity was also carried out to determine the presence of unit root in the series. Identification of the model was achieved using autocorrelation function (ACF) and partial autocorrelation function (PACF) plots and the best model found using the least mean absolute deviation (MAD) and mean square error (MSE) and the best time series model was estimated. The result is thus presented in this section. The summary statistics of monthly RTA categories (types) and outcomes are presented in tables 1-2 while trends of monthly RTA categories and outcomes with their corresponding monthly cumulative RTA categories and outcomes are presented in figures 1-4 below.

Table 1 Summary Statistics of Monthly Road Traffic Accident (RTA) Categories in Kogi State

RTA Categories	Minimum	Maximum	Sum	Mean	S.D.	Skewness	S.E	Kurtosis	S.E
January									
Fatal	6	13	41	8.20	2.864	1.584	.913	2.739	2.000
Serious	14	24	87	17.40	4.159	1.301	.913	.788	2.000
Minor	2	11	30	6.00	3.317	.685	.913	1.132	2.000
February									
Fatal	3	7	25	5.00	1.581	.000	.913	-1.200	2.000
Serious	7	17	72	14.40	4.219	-2.029	.913	4.217	2.000
Minor	2	11	28	5.60	3.782	.793	.913	-1.253	2.000
March									
Fatal	6	10	39	7.80	1.643	.518	.913	-1.687	2.000
Serious	11	23	90	18.00	4.472	-.978	.913	1.513	2.000
Minor	4	11	36	7.20	3.114	-.060	.913	-2.299	2.000
April									
Fatal	1	13	33	6.60	4.393	.418	.913	.966	2.000
Serious	9	21	76	15.20	4.324	-.226	.913	1.337	2.000
Minor	2	6	22	4.40	1.517	-1.118	.913	1.456	2.000
May									
Fatal	7	11	45	9.00	2.000	.000	.913	-3.000	2.000
Serious	15	22	96	19.20	3.033	-.763	.913	-1.841	2.000
Minor	2	8	24	4.80	2.168	.422	.913	1.435	2.000
June									
Fatal	4	9	30	6.00	1.871	1.145	.913	2.000	2.000
Serious	7	23	86	17.20	6.340	-1.235	.913	1.658	2.000
Minor	3	8	28	5.60	2.510	-.196	.913	-3.031	2.000
July									
Fatal	5	10	35	7.00	1.871	1.145	.913	2.000	2.000
Serious	13	18	76	15.20	2.168	.559	.913	-2.368	2.000
Minor	1	9	28	5.60	3.209	-.608	.913	-.681	2.000
August									
Fatal	4	9	33	6.60	1.817	-.267	.913	1.074	2.000
Serious Accident	13	22	86	17.20	3.421	.280	.913	-.090	2.000
Minor Accident	4	10	29	5.80	2.387	2.043	.913	4.423	2.000

September									
Fatal Accident	4	8	28	5.60	1.673	.512	.913	-.612	2.000
Serious Accident	6	12	50	10.00	2.550	-1.207	.913	.580	2.000
Minor Accident	3	8	25	5.00	2.345	.581	.913	-2.628	2.000
October									
Fatal Accident	2	6	24	4.80	1.643	-1.736	.913	3.251	2.000
Serious Accident	9	17	61	12.20	3.114	.933	.913	.762	2.000
Minor Accident	2	7	18	3.60	2.074	1.447	.913	1.931	2.000
November									
Fatal Accident	5	8	32	6.40	1.140	.405	.913	-.178	2.000
Serious Accident	11	17	67	13.40	2.191	1.293	.913	2.917	2.000
Minor Accident	1	8	19	3.80	2.775	.927	.913	.130	2.000
December									
Fatal Accident	8	11	50	10.00	1.414	-.884	.913	-1.750	2.000
Serious Accident	15	46	132	26.40	12.740	1.009	.913	.383	2.000
Minor Accident	6	8	33	6.60	.894	1.258	.913	.313	2.000

Source- Authors' analysis

Table 2 Summary Statistics on Monthly RTA Outcomes in Kogi State

RTA Outcomes	Minimum	Maximum	Sum	Mean	Std. Dev.	Skewness	Std. Er.	Kurtosis	Std. Er.
January									
Injury	84	142	536	107.20	26.052	.701	.913	-2.318	2.000
Death	8	24	89	17.80	6.058	-1.254	.913	2.031	2.000
Safe	82.00	229.00	763.00	152.6000	67.88814	.345	.913	-2.917	2.000
February									
Injury	62	81	369	73.80	7.362	-1.244	.913	1.540	2.000
Death	4	23	70	14.00	8.155	-.111	.913	-2.274	2.000
Safe	78.00	146.00	536.00	107.2000	25.82053	.716	.913	.618	2.000
March									
Injury	74	162	565	113.00	44.486	.565	.913	-3.263	2.000
Death	14	45	121	24.20	12.071	1.829	.913	3.720	2.000
Safe	110.00	168.00	656.00	131.2000	23.70021	1.010	.913	.730	2.000
April									
Injury	29	112	378	75.60	30.640	-.716	.913	1.258	2.000

Death	1	21	70	14.00	7.714	-1.618	.913	3.028	2.000
Safe	30.00	162.00	526.00	105.2000	53.07259	-.467	.913	-.710	2.000
May									
Injury	66	131	480	96.00	23.791	.478	.913	1.051	2.000
Death	8	28	90	18.00	7.906	.000	.913	-1.200	2.000
Safe	95.00	197.00	764.00	152.8000	48.49433	-.531	.913	-3.032	2.000
June									
Injury	57	122	457	91.40	25.245	-.355	.913	-.753	2.000
Death	4	21	72	14.40	7.232	-.803	.913	-1.145	2.000
Safe	148.00	275.00	942.00	188.4000	50.59941	1.786	.913	3.375	2.000
July									
Injury	68	121	454	90.80	20.511	.608	.913	.128	2.000
Death	12	23	87	17.40	4.159	.050	.913	-.175	2.000
Safe	100.00	190.00	694.00	138.8000	35.78687	.627	.913	-.685	2.000
August									
Injury	77	101	453	90.60	8.678	-.876	.913	2.129	2.000
Death	8	20	75	15.00	4.848	-.593	.913	-.535	2.000
Safe	115.00	232.00	870.00	174.0000	47.79644	.124	.913	-1.745	2.000
September									
Injury	43	99	412	82.40	22.843	-1.868	.913	3.594	2.000
Death	12	35	108	21.60	8.385	1.060	.913	2.316	2.000
Safe	62.00	190.00	605.00	121.0000	54.95453	.453	.913	-2.380	2.000
October									
Injury	37	83	320	64.00	18.111	-.769	.913	.049	2.000
Death	3	21	73	14.60	7.301	-1.276	.913	.949	2.000
Safe	39.00	261.00	665.00	133.0000	82.41662	.884	.913	1.481	2.000
November									
Injury	43	103	361	72.20	21.417	.182	.913	1.668	2.000
Death	6	21	73	14.60	5.505	-.900	.913	1.777	2.000
Safe	53.00	112.00	379.00	75.8000	22.26432	1.297	.913	2.169	2.000
December									
Injury	91	181	658	131.60	43.322	.517	.913	-3.140	2.000
Death	18	32	121	24.20	5.586	.440	.913	-.871	2.000
Safe	81.00	383.00	1026.00	205.2000	138.71265	.509	.913	-2.489	2.000

Sources- Authors' analysis

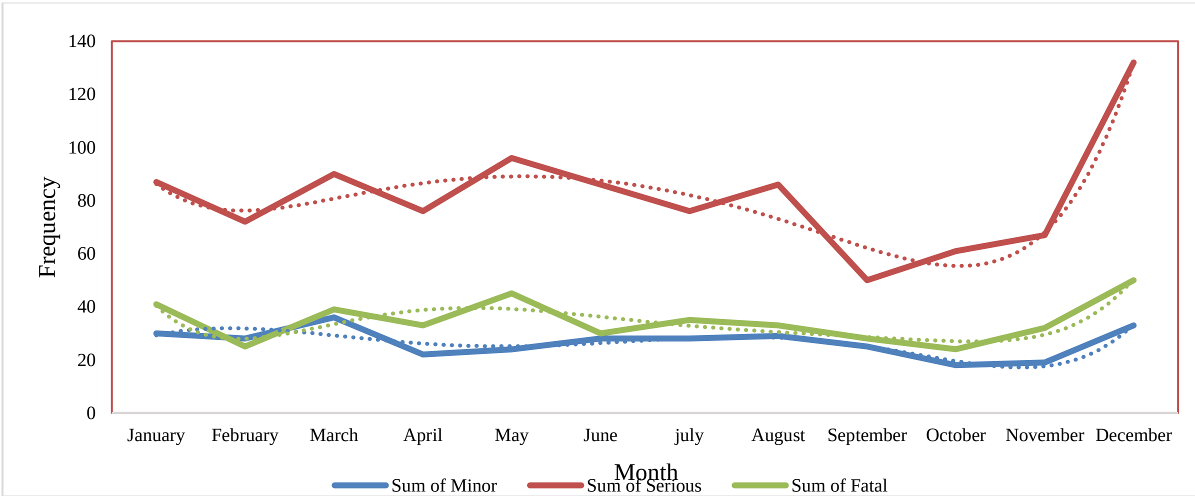

Fig. 1 Trend showing pattern of monthly RTA categories

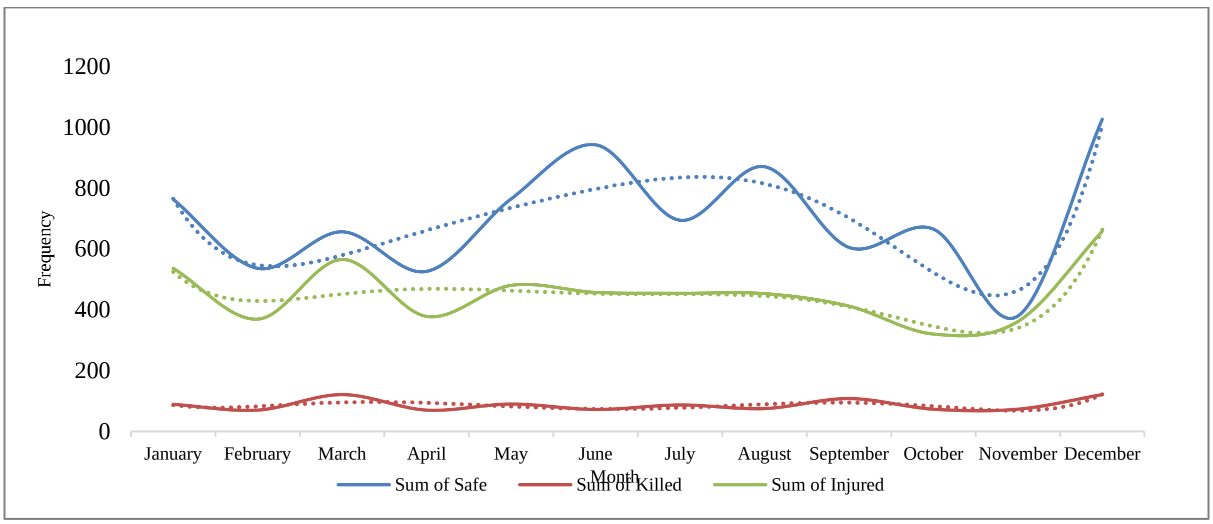

Fig. 2 Trend showing pattern of monthly RTA outcomes

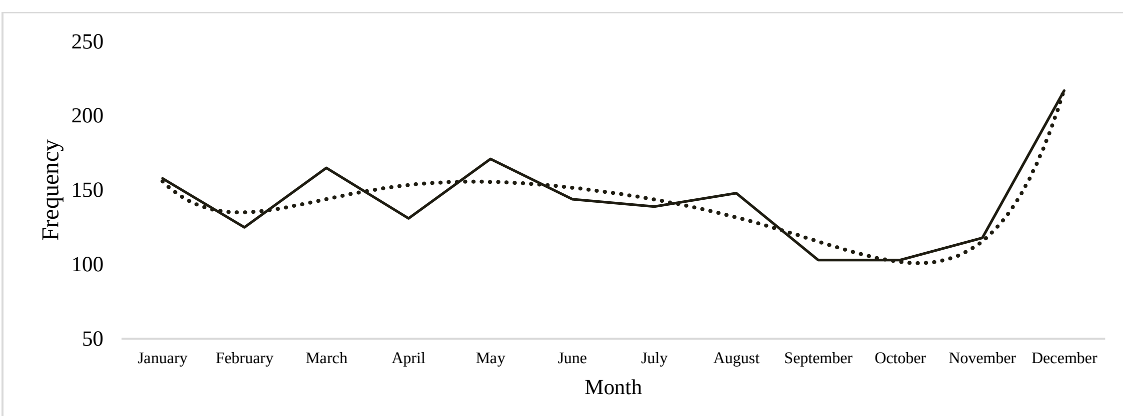

Fig. 3 Trend showing pattern of cumulative RTA categories

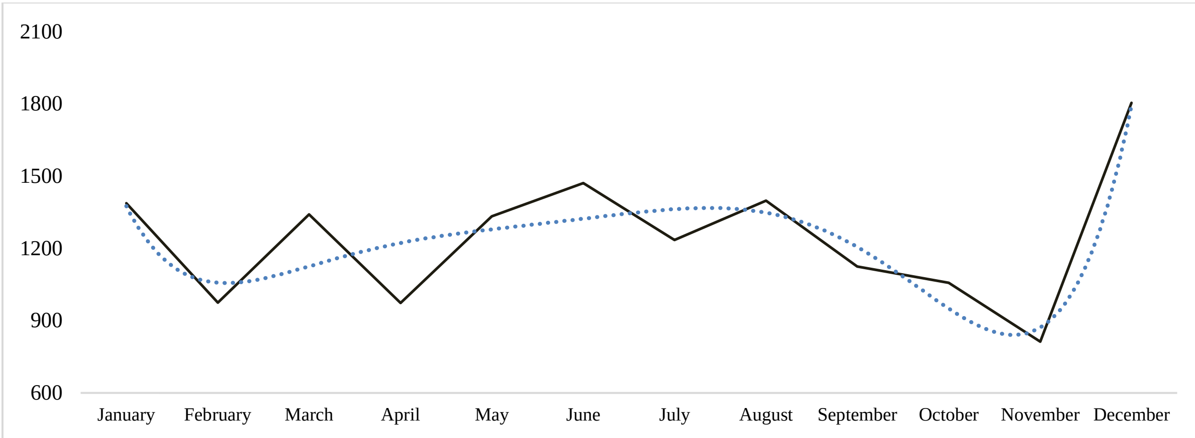

Fig. 4 Trend showing pattern of cumulative RTA outcomes

From the Summary statistics of monthly RTA categories (types) and monthly RTA outcomes were presented in Tables 1-2, it is obvious that the latter months of the year and early part of the year (that is, from November to January) had the highest number of instances, particularly serious accidents. Additionally, it was seen that the rates began to fluctuate from February to October. From figures 1-4, it is also clear that the trend of both cumulative RTA types and outcomes show similar movement and pattern. The trend plots in general, show an increasing trend in all three RTA types and outcomes from November to January while steady fluctuations were observed from February to October. To understand the underlying reasons for these fluctuations, the test of stationarity was carried out on the cumulative accident categories. The result is thus presented in Table 3.

Table 3 Test of Stationarity

Parameter	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value	P-value
Z(t)	-6.163	-3.567	-2.923	-2.596	0.000

Source-Authors' analysis

From table 3 where the test of stationarity of the RTA series was conducted using the augmented Dickey-Fuller test, the p-value of augmented Dickey-Fuller (ADF) statistic was found to be 0.000 which is less than the specified critical value α =0.05. This implies that the monthly RTA series is stationary and there is no significant unit root in the series.

Autocorrelation and partial autocorrelation functions were then plotted in figures 5a-b to determine the number of lags required to obtain potential (candidate) models for the RTA (categories).

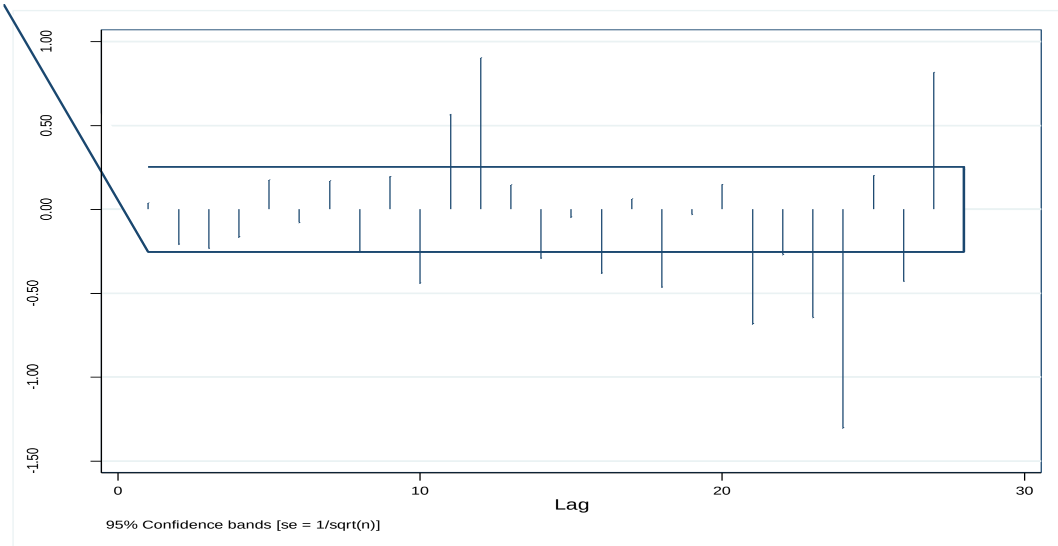

Fig 5a Partial Autocorrelation function plot for RTA series

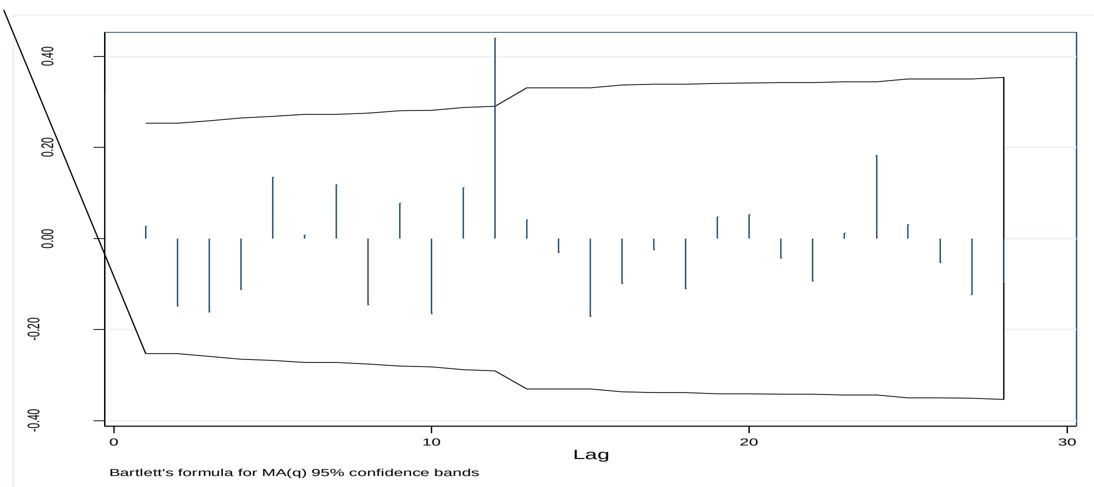

Fig. 5b Autocorrelation function plot for RTA series

From figures 5a-b, it is obvious that there were 10 potential AR models and 1 potential MA model to be included in the model based. The ACF shows steady decay while the PACF sharply dropped after the first spike. This patterns and the fact that the data was originally stationary led to the choice of ARMA with candidate models (1,0,1), (2,0,1), (3,0,1), (4,0,1), (5,0,1), (6,0,1), (7,0,1), (8,0,1), (9,0,1) and (10,0,1). The choice of the best fitted model from the array of candidate models was made using the least mean absolute deviation (MAD) and mean square error (MSE) and the result thus presented in Table 4.

Table 4 Possible Fitted Models

Model	MAD	MSE
1,0,1	**29.68424**	**881.1541**
2,0,1	31.83356	1013.376
3,0,1	31.65566	1002.081
4,0,1	35.84481	1284.85
5,0,1	36.31668	1318.901
6,0,1	33.054	1092.567
7,0,1	38.87574	1511.323
8,0,1	40.96001	1677.722
9,0,1	42.03311	1766.782
10,0,1	41.43048	1716.485

Source-Authors' analysis ***Note****-The bold model represents the model with the least MAD & MSE*

From table 4, the best model among the candidate models was found to be ARIMA (1,0,1). Also, a test of normality was conducted on both the monthly RTA series and its residual in Table 5.

Table 5 Shapiro-Wilk normality test

Variable	Observation	W	V	z	p-value
RTA	60	0.9337	3.604	2.763	0.00286
Residual	60	0.95276	2.568	2.033	0.02103

Source-Authors' analysis

Table 5 shows that both the RTA and its residual are non-normal since the p-values are less than the critical value of 0.05 in both cases. As a result, the least absolute deviation (LAD) estimator was used to obtain the parameters of ARMA (1,1) since the RTA data and its residual were found to be non-normal at 0.05 level of significance (Portnoy & Koenker, 1997). The result of this estimation is thus presented in Table 6.

Table 6 Parameter Estimation of ARMA (1,1)

Variable	Coefficient	Std. Err.	Z	*p*>z	[95% Conf.	Interval]
Constant	29.010574	2.209168	13.15	0.000	24.72751	33.38729
AR1.	0.492151	0.124647	3.95	0.000	0.247848	0.736453
MA1.	0.99994	0.116917	8.55	0.000	0.770786	1.229093
/sigma	4.536992	.	.	.	.	.

Source-Authors' analysis

From Table 6, $Y_t = 29.0574 + 0.492151X_{t-1} + 0.99994e_{t-1} + \varepsilon_t$ is the estimated ARMA (1,1) model which is statistically significant given the fact that the *p*-values of the AR and MA terms are less than the critical value of 0.05.This implies that ARMA (1,1) provides a good fit for the RTA series. The estimated ARIMA (1,0,1) model (or ARMA(1,1) is thus used for forecasting of monthly RTA with 95percent confidence level, for further 30months with the results presented numerically in Table 7 and pictorially in fig. 6.

Table 7 A Thirty-Month Prediction of Road Traffic Accident

Month in Year	Predictions	Lower Boundaries	Upper Boundaries
22-Jan	39	37.24164	41.65998
22-Feb	31	28.48187	32.90021
22-Mar	42	40.22889	44.64722
22-Apr	4	2.199623	6.617959
22-May	29	27.08482	31.50315
22-Jun	31	28.29462	32.71296
22-Jul	40	37.98772	42.40606
22-Aug	29	26.71325	31.13159
22-Sep	31	28.57109	32.98943
22-Oct	13	10.77214	15.19048

22-Nov	27	25.12601	29.54434
22-Dec	54	51.97589	56.39423
23-Jan	34	31.96336	36.38169
23-Feb	30	27.65223	32.07057
23-Mar	36	33.43353	37.85186
23-Apr	17	14.71741	19.13574
23-May	29	26.96467	31.38301
23-Jun	30	27.56008	31.97841
23-Jul	35	32.33054	36.74887
23-Aug	29	26.7818	31.20014
23-Sep	30	27.69614	32.11448
23-Oct	21	18.93638	23.35471
23-Nov	28	26.00064	30.41897
23-Dec	41	39.21483	43.63316
24-Jan	32	29.36565	33.78398
24-Feb	29	27.24392	31.66226
24-Mar	32	30.08919	34.50753
24-Apr	23	20.87804	25.29638
24-May	29	26.90554	31.32388
24-Jun	29	27.19857	31.6169

Source-Authors' analysis

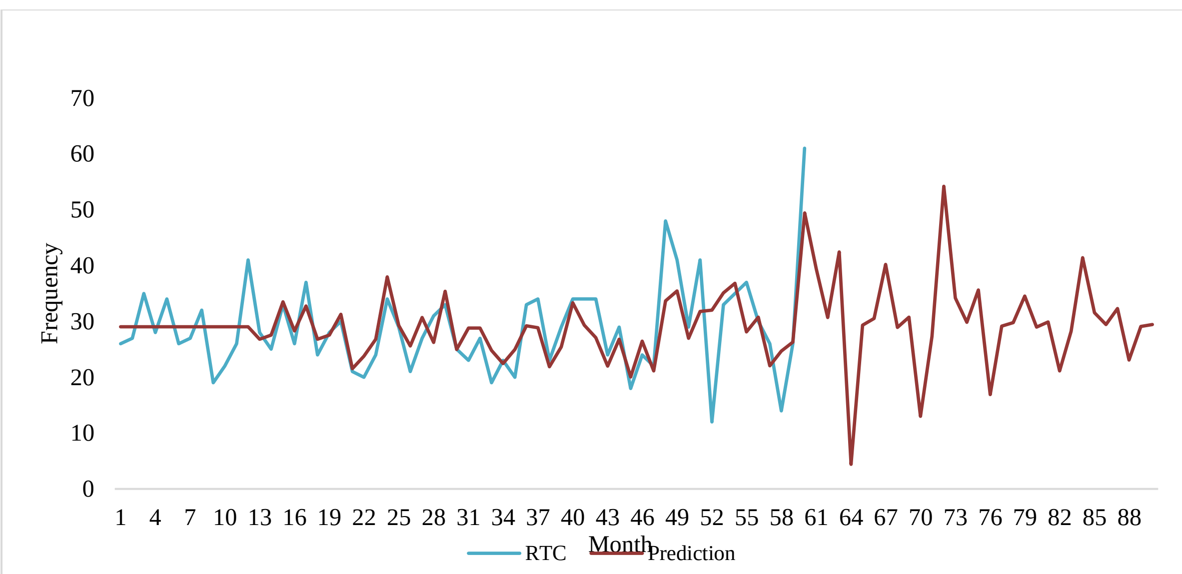

Fig. 6 Forecast model values superimposed on original values' plot

Table 7 shows the 30-month prediction of RTA and its corresponding 95percent confidence interval from January 2022 to June 2024. These forecast figures shows steady fluctuation in the monthly occurrence rates of RTA. Also, Fig. 6 also shows that the actual and predicted values intersect and there is a steady fluctuation in the series with upward trend at specific months. These imply that the forecast values are very good and the RTA series will continue to fluctuate and never stagnate. To ascertain the extent to which RTA types have impacted on travelers' lives over time, Pearson correlation was used to examine the degree of relationship between monthly RTA types and outcomes, and the result is presented in table 8.

Table 8 Test of Relationship between RTA types and outcomes

Variable	Injury	Death	Safe/no injury
Fatal Accident	**.421**	**.708**	**.272**
	(.001)	(.001)	(.003)
Serious Accident	**.613**	.212	**.486**
	(.000)	(.104)	(.000)
Minor Accident	**.338**	.181	.633
	(.008)	(.165)	(.073)

Source- Authors' analysis *bold indicates statistical significance at $p < 0.05$*

From Table 8, the results written in bold indicate a significant correlation among the pairs considered at 0.05 level of significance. However, it can be said that:

- There are significant positive linear relationships between all RTA types (fatal, serious and minor accident) and level of injury sustained.
- There is a significant positive linear relationship between fatal accident and death

- There is a significant positive linear relationship between fatal accident and no injury
- There is a significant positive linear relationship between serious accident and no injury
- There is an insignificant positive linear relationship between serious accident and death, minor accident and death as well as minor accident and no injury.

By observing a significant positive linear relationship between pairs, we mean there exists a positive linear relationship which is significantly different from zero

4. DISCUSSIONS

The summary statistics in tables 1-2 and figures 1-4 show steady fluctuations in monthly RTA types and outcomes from February to October. Steady fluctuations were observed between February and October while upward trend were observed from November to January. The upward trend in RTA from November to January is not surprising given its coincidence with the Yuletide season and 'confluence' nature of the state. Being the connection between the Northern, Western, Eastern and Southern regions of the country, and particularly sharing boundaries with several states, there were higher volumes of commuters and vehicles traversing southwardly, northwardly, eastwardly and westwardly to various parts of the country for the Yuletide season and holidays. Apart from the fact that it coincides with a period in which most travellers often travel to celebrate the yuletide season (with family and friends) in various destinations (states, towns, villages or cities), it also coincides with the time when majority of students are on break and have to travel home. Workers have to travel to their home towns away, from their work places to spend the holiday and celebrate the season with their families and friends. The augmented Dickey-Fuller (ADF) test was used to ascertain the presence of unit root in the cumulative RTA series. The ADF test shown in table 3 revealed that the cumulative monthly RTA series was stationary at 0.05level of significance. This led to the adoption of ARMA

(ARIMA p,0,q) model for the series. Following all the steps in the Box-Jenkins approach, it was found that ARIMA (1,0,1) was selected (based on selection criteria i.e MAD and MSE) as the best among all the candidates models obtained using patterns on the ACF and PACF. Since the RTA series and its residual were found to be non-normal based on Shapiro-Wilk test in Table 5, the least absolute deviation (LAD) estimator was used to obtain the parameters of best (fitted) model in Table 6 as $Y_t = 29.0574 + 0.492151X_{t-1} + 0.99994e_{t-1} + \varepsilon_t$. The fitted model was found to be statistically significant at 0.05level of significance. Since from Table 6 in the estimation of the model, it is clear that the past one month value t-1 (November 2021) of RTA series for the AR term and the random shocks in the MA term are related to the RTA series in the current time t (December 2021), and were statistically significant as their p-values are less than the specified critical value $\alpha=0.05$. Also, forecast of 30 months was made for RTA series from January 2022- June 2024. As shown in Table 7, the forecast series were within the 95% confidence bounds. From Fig 6, both the actual RTA values and forecast values intersect from the beginning of the study period in January 2017 to the end in December 2021. Thus, it reveals that the forecast values were good. Like the original RTA series, there was steady fluctuation in the forecast series at some months and an upward trend at some months, this shows the series will continue fluctuating at specific months (February to October) with non-zero values and will trend upward at other months (November to January) for these forecasted time period. This implies that the RTA rates will continue to fluctuate in the state and occurrence of road traffic crashes will continued to be witnessed. Particularly, there will be higher rate of accidents at the specific period where upward trend (of RTA) was observed.

Results of the test of relationship between RTA types and outcomes show that there exist strong positive relationship that is significantly different from zero between fatal accident and death and between serious accident and injury sustained while there exist a weak positive relationship that is significantly different from zero between fatal accident and injury as well as fatal accident and no injury. There also exists a weak positive relationship between minor accident and injury and between serious accident and no injury.

In particular, there is about 71 percent likelihood that a fatal accident will result in death outcomes, there is a about 61percent likelihood that a serious accident will result in injury whereas there is a 63percent likelihood that a minor accident will result in no injury. The table shows that there is a statistically significant weak relationship between minor accidents and injury suffered, a statistically insignificant weak relationship between minor accidents and death, a statistically insignificant strong relationship between minor accidents and no injury.

5 CONCLUSION

This study statistically models from January 2017 to December 2021 and forecasts road traffic accident from January 2022 to June 2024 in Kogi State using time series technique. It also analyses the relationship between road traffic accident categories and outcomes using Pearson correlation. The findings show that rate of RTA fluctuates steadily for most past of the months from February to October and trended upwardly in certain months from November to January. The upward trend in RTA was attributed to the confluence nature of the state characterized by high volume of commuters and vehicles in the Yuletide season. Following the steps in the time series methodology of identification, selection and estimation, the best model was found to be ARIMA (1,0,1) after it was adjudged to be stationary. The parameters of the best model were estimated by LAD owing to the non-normal nature of the series and its residuals. The estimated ARIMA (1,0,1) model was found to be $Y_t = 29.0574 + 0.492151X_{t-1} + 0.99994e_{t-1} + \varepsilon_t$ which is statistically significant at 0.05level of significance. As a result, it was used for forecasting of 30 month RTA with 95 percent confidence level from January 2022 to June 2024. The forecast showed steady fluctuation at most parts of the months with upward trend at some months.

It was found to be good since the forecasted values were within the bound and there were intersection between the original and predicted values from the beginning to the end of the study period. This lead us to conclude that the RTA rates will continue to fluctuate in the state and occurrence of road traffic crashes will continue to be witnessed. Particularly, there will be higher rate of accidents at the specific period where upward trend (of RTA) was observed. It can be concluded that fatal accident will most likely be associated to death and in some cases injury, serious accident will more likely be associated to injury or no injury in some cases while minor accident will most likely be associated to no injury.

Authors' contributions

O.Y. conceived and initiated the research idea, T.A. sourced for the data while A.O. developed the theory and performed the computations. T.A. collated the results and wrote the manuscript. Both O.Y. and A.O. edited the manuscript.

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Declaration of Competing Interest

The authors declare that no competing interests exist.

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