

# SPATIO-TEMPORAL VARIATION IN ROAD TRAFFIC ACCIDENTS ALONG HIGHWAYS IN KADUNA STATE, NIGERIA

BY

Lawal, A.M.<sup>1\*</sup>, Okere, D.C.<sup>2</sup> and Akpu, B.<sup>3</sup>

<sup>1</sup>Department of Surveying & Geo-informatics, Kaduna Polytechnic, Kaduna

<sup>2</sup>Department of Geography, University of Nigeria, Nsukka

<sup>3</sup>Department of Geography & Environmental Management, Ahmadu Bello University, Zaria

\*Corresponding Author's Email: [survng@yahoo.com](mailto:survng@yahoo.com)

## ABSTRACT

Road traffic accidents (RTAs) are often found to follow some spatial and temporal patterns as the factors that influence road accident changes with space and time. The aim of the paper is to analyze the spatio-temporal variation in road traffic accidents along Kaduna-Abuja and Kaduna-Birnin Gwari highways in Kaduna state. The study used road traffic accident records between years 2010 to 2014 from Federal Road Safety Corps and google earth satellite imagery. Handheld GPS was used to acquire the absolute location of road traffic accident. Descriptive statistics and Average Nearest Neighbour statistical tool in ArcGIS 10.1 was used to analyze the data. The results of the analysis revealed that 336 accidents were recorded along the two routes, with 66% recorded along the Kaduna-Abuja road while 34% occurred on the Kaduna-Birnin Gwari road. The nearest neighbour index (0.135 and 0.229) showed a clustered pattern of road traffic accidents distribution along Kaduna-Abuja and Kaduna-Birnin Gwari highways respectively. The temporal analysis revealed a clear seasonal variation in the occurrence of accidents on the routes. Most of the accidents occurred during festive months. Also the highest RTAs were recorded in 2011 for both routes with 37.8% along Kaduna-Abuja while 47.4% accounted for Kaduna-Birnin Gwari road. Strict enforcement of safety measures like drivers' use of speed limit devices among others and public education programme by FRSC on road safety especially during festive periods is recommended.

**Key words:** Accident, Nearest neighbour ratio, Road traffic

## INTRODUCTION

The daily activities of human beings revolve around one form of transportation or another hence the movement from a particular location to another. This movement of people and goods from one point to another requires the use of different means of transportation, road inclusive. According to International Transport Forum [ITF] (2014) road transportation is basically the most utilized means of land transport accounting for over 70 per cent of the movement of persons and goods globally. On the other hand, Bolade and Ogunsanya (1991) argued that one of the unavoidable negative impacts of road transport is accident occurrence. It is often said that Road Traffic Accidents [RTAs] have become common on Nigerian roads.

According to Agbeboh and Osarumwense (2013), RTA is an unplanned occurrence of auto crash that may result in injuries, loss of lives and properties. Schwela (2008) defined road traffic

accident as an unexpected collision between two or more road users as occasioned by either deficiency in traffic management system, human incapability, mechanical inefficiencies or poor environmental condition, often resulting to various degrees of injuries, loss of lives and damages to properties.

Road traffic accident claims the largest toll of human life and tends to be the most serious problem all over the world (Kual et al., 2005). Worldwide, the number of people killed in RTA each year is estimated at almost 1.2 million while the number of people injured could be as high as 50 million (World Health Organization [WHO], 2004). Currently, motor vehicle accidents rank 9th in order of disease burden and are projected to be ranked 3rd in the year 2020. In Nigeria, Federal Road Safety Corps [FRSC] (2017) reported that in the year 2016, a total of 9694 road traffic crashes were recorded out of which 2,638 cases were fatal, 5,633 were serious cases and 1,423 cases were minor. It was further reported that Kaduna State had the highest fatality in road traffic crashes in 2016 with 715 crashes, 505 persons killed and 2,849 persons injured. Also the route variation shows that Kaduna-Abuja road recorded relatively high number of deaths among other federal highways in the country. This situation has become worrisome and a source of concern to all stakeholders given its negative effects on the development of the state.

World Bank (1999) was of the view that the incidence of road accidents and fatalities vary at both spatial and temporal scales. Similarly, Shamsuddin et al. (2015) stated that the number of road accidents varies with time and often found to follow a pattern. Therefore, road accident incidence changes continually with time and space. It is of vital importance to analyze road traffic accidents in both spatial and temporal scales in order to improve traffic security management (Gao et al., 2012). Empirical studies have been carried out across the world to analyze spatial and temporal pattern of road traffic accident. Zhang et al. (2015) reported that zonal factors such as traffic behaviour, land use, transportation facility, and demographic features defined the spatial variability of accident. Chaney and Kim (2014)'s study on the temporal variations of collision in Ohio (USA) shows higher rates of collision during summer period.

Kaduna State serves as a link to other cities in the northern and southern parts of the country, as a result experience several inner and outer movements. This is often on the increase especially during the festive periods of Sallah and Yuletide. Movement during this peak period is one of the factors that inundate the traffic landscape with RTAs along the major highways in Kaduna State (Balogun, 2013). Among the major highways in Kaduna state is Kaduna-Birnin Gwari (single carriage way) popularly known as Lagos Road and Kaduna-Abuja (dual carriage way) linking the Federal Capital Territory [FCT] Abuja. A cursory observation shows the poor conditions of Kaduna-Birnin Gwari highway while the Kaduna-Abuja highway has a relatively good roadway conditions which might encourage over speeding resulting to tyre burst and brake failure. However, the different road conditions and high volume of traffic along the two highways might have a varied effect on the occurrence of RTA over time and space hence, the need to study the spatio-temporal variation of RTA along the two highways.

Steenberghen et al. (2004) stated that Geospatial Information Systems [GIS] as a tool can be used to map accident location/patterns in relation to the number of accident spots or the numbers of accidents per period. This study applied Remote Sensing and GIS in analyzing the spatial and temporal variation of road traffic accidents along Kaduna-Birnin Gwari and Kaduna-Abuja highways

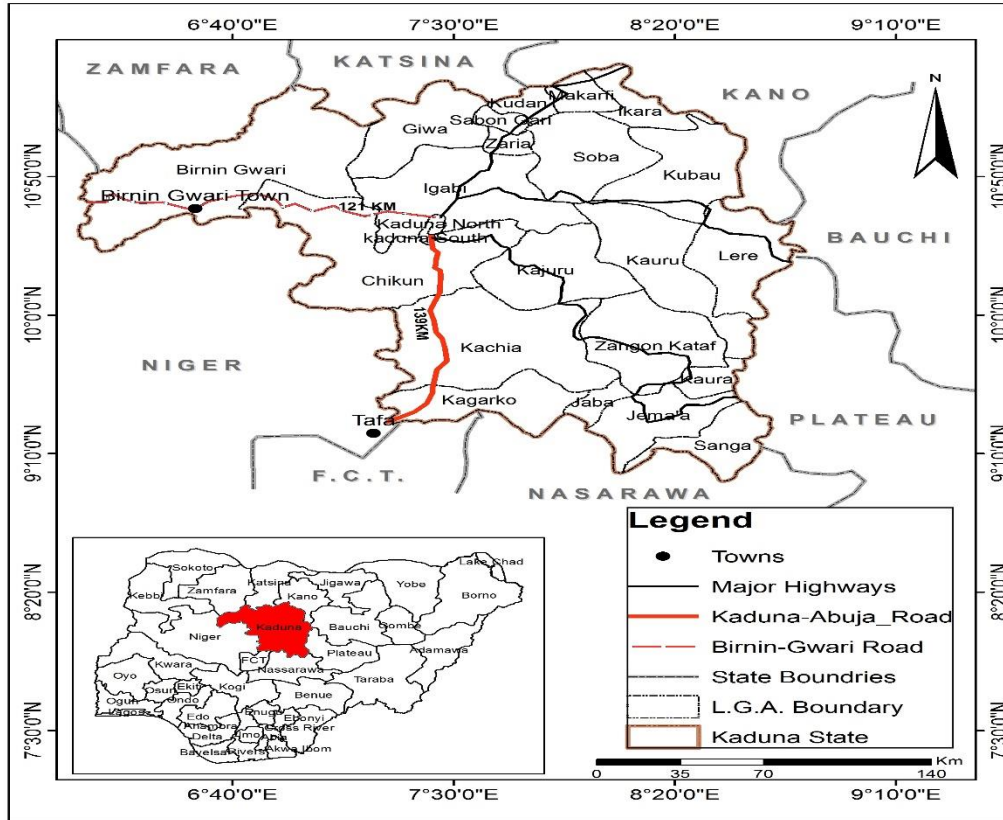
in Kaduna State. The objectives of the study is to examine the spatial and temporal variation in the incidence of road traffic accidents as well as determine its spatial pattern along the study routes.

## **MATERIALS AND METHOD**

Kaduna-Abuja road is located between Latitudes 9° 20' N - 10° 29' N of the Equator and Longitudes 7° 14' E - 7° 25' E while the Kaduna-Birnin Gwari road is located between Latitudes 10° 35' N – 10° 40' N and Longitudes 6° 17' E – 7° 26' E of the Greenwich meridian. Kaduna-Abuja road has a distance of about 139km from Abuja junction Kaduna to Tafa while Kaduna-Birnin Gwari road covers an approximate distance of 121km from Mando Roundabout (Kaduna) to Birin Gwari town. Kaduna state is bounded to the north by Kano, Katsina and Zamfara States to the west by Niger State, to the east by Bauchi State and to the south by Nasarawa and Plateau States (OSGOF, 2011). The state occupy a land mass of about 48, 473.2km<sup>2</sup> (Figure 1).

The relief of Kaduna State consists mainly of the Precambrian rocks of the basement complex (Barbour, 1982). It is mainly drained by two rivers namely; river Kaduna and river Gurara, which is sourced at Kwal on the north central Jos plateau. The state experiences a tropical continental climate characterized by two distinct alternating wet and dry seasons. The rainy season usually begins from March/April and runs through September/October. The rainfall amounts falls between 1100-1300 mm (Parkman International Association, 1997). In the year 2006, Kaduna state had a population of 6,066,562 (National Population Commission [NPC], 2009). Using 3.07% inter-census growth rate, the 2017 projected population of Kaduna State stands at 9,184,341. Kaduna is the second largest commercial town after Kano in the north. Road transport has been one of the most prominent transport systems in Kaduna state especially in recent times. It has served as a catalyst for economic development all over the state. The state has a network of local, state and federal roads.

Road traffic accident records between years 2010 to 2014 were obtained from of the Federal Road Safety Commission. The absolute location of road traffic accident along the study area was acquired using a handheld GPS receiver during the field survey. The geographic coordinates of road traffic accidents locations was overlaid in ArcGIS environment on the geo-referenced and digitized routes network map from the google earth satellite imagery in order to show the distribution of RTA. Descriptive statistics was used to examine the periods of road traffic accidents as extracted from the FRSC road traffic accidents record.



**Figure 1: Kaduna State Showing the Study Routes**

Source: Adapted from the Administrative Map of Kaduna State

The Average Nearest Neighbour statistical tool in ArcGIS 10.1 was used to determine the spatial pattern of RTA. The pattern of distribution of road traffic accident was determined using the average nearest neighbour in spatial statistic toolbox of ArcGIS version 10.1 environment. The average nearest neighbour analysis calculates the nearest neighbour index (which is a measure of the distance between each accident centroid and its nearest neighbour's centroid location. It then averages all these nearest neighbour distances). These parameters were used as the basis for the determining whether the distribution is clustered, dispersed or random.

## RESULTS AND DISCUSSION

### Spatial Distribution of Road Traffic Accidents

Table 1 shows the frequency of accidents on Kaduna-Abuja Road and Kaduna-Birnin Gwari road. It indicates that 66% of the accidents were recorded on Kaduna-Abuja road while 34% occurred on Kaduna-Birnin Gwari Road. This implies that there was a higher frequency of accidents on the dual carriage way (Kaduna-Abuja) than on the single lane road (Kaduna-Birnin Gwari). The result may be attributed to the higher volume of traffic along the Kaduna-Abuja road and given the assertion that higher traffic volume increases the risk of vehicular accidents.

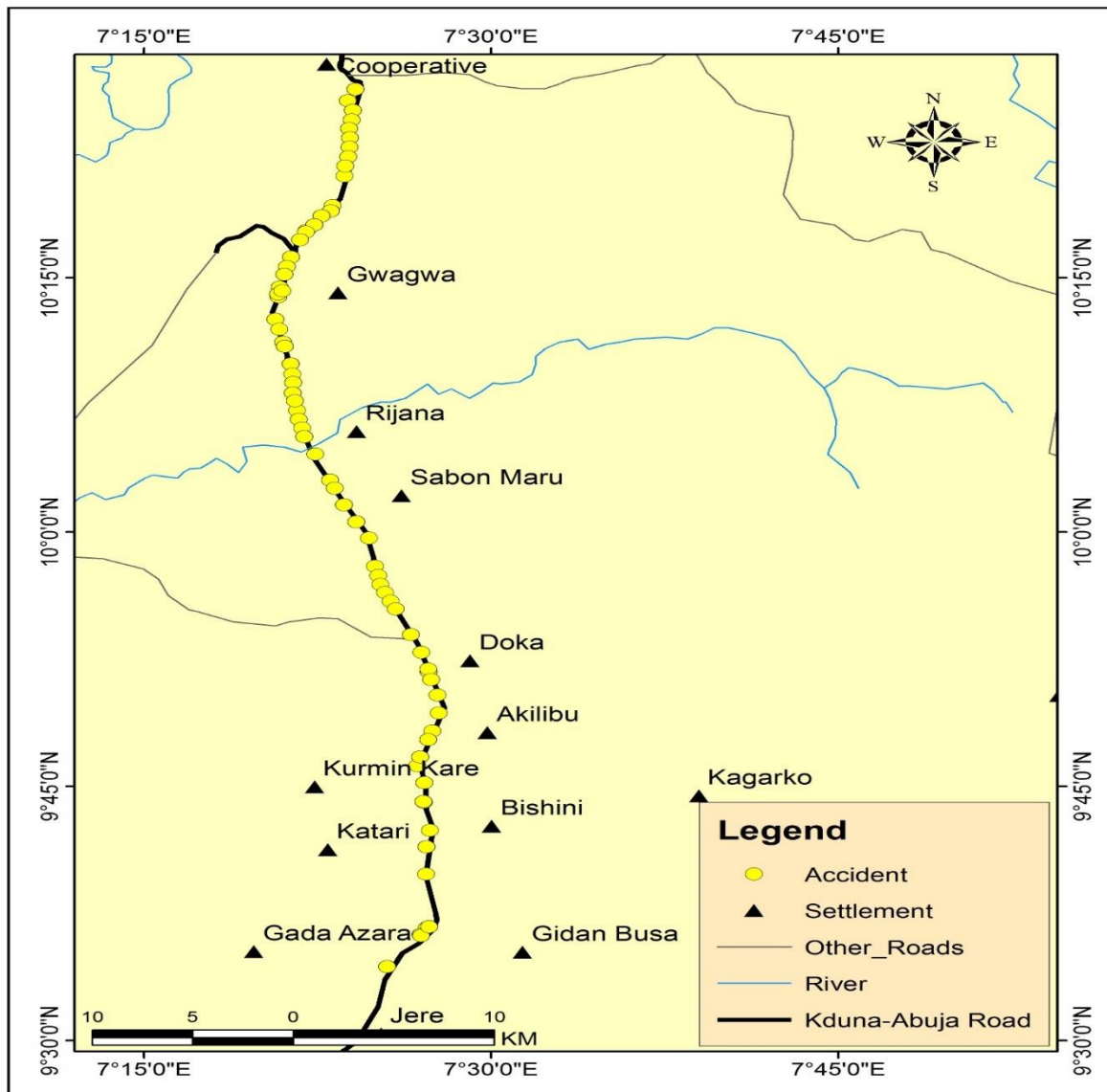
This finding is similar to that of Rukewe et al. (2014) which found that road crashes significantly differed between dual and non-dual carriage roads within Ibadan metropolis with dual carriage roads accounting for 54.3% while 45.7% occurred on non-dual carriage roads. The distribution of

road traffic accidents along Kaduna-Abuja and Kaduna-Birnin Gwari roads is further presented in Figures 2 and 3 respectively.

**Table 1: Frequency of Road Traffic Accidents**

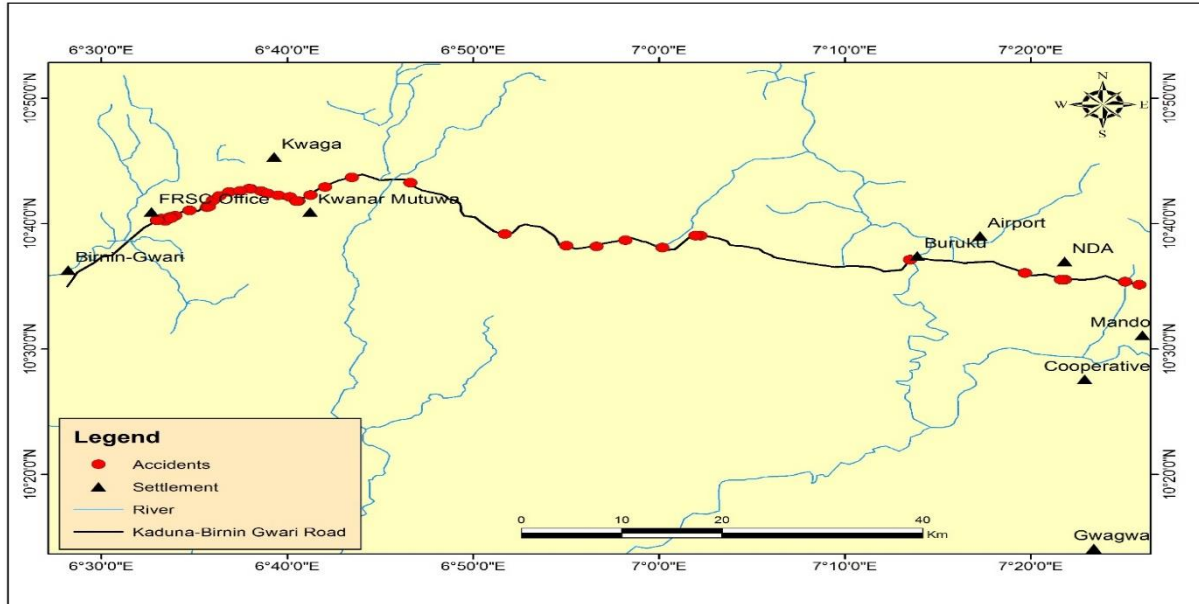
Route	Frequency	Percent
Kaduna-Abuja Road	222	66.0
Kaduna-Birnin Gwari Road	114	34.0
<b>Total</b>	<b>336</b>	<b>100</b>

Source: Authors Analysis from FRSC Records, 2017



**Figure 2: Distribution of Accidents Location along Kaduna-Abuja Road**

Source: Authors Analysis from FRSC Records, 2017.



**Figure 3: Distribution of Accidents Location along Kaduna-Birnin Gwari Road**

Source: Authors Analysis from FRSC Records, 2017.

### Yearly Variation of Road Traffic Accident

Table 2 reveals that the highest road traffic accidents cases were recorded in the year 2011 which accounted for 37.8% and 47.4% on the Kaduna-Abuja road and Kaduna-Birnin Gwari road respectively. This indicates a significantly high occurrence of road traffic accidents in year 2011 in the study area. The possible explanation for this could be the fact that it was an election year in which several journeys were made which might have increased the number of road traffic accidents. Also the year 2010 accounted for the least RTAs on the Kaduna-Abuja road (10.6%) and 2014 on the Kaduna-Birnin Gwari road (13.1%).

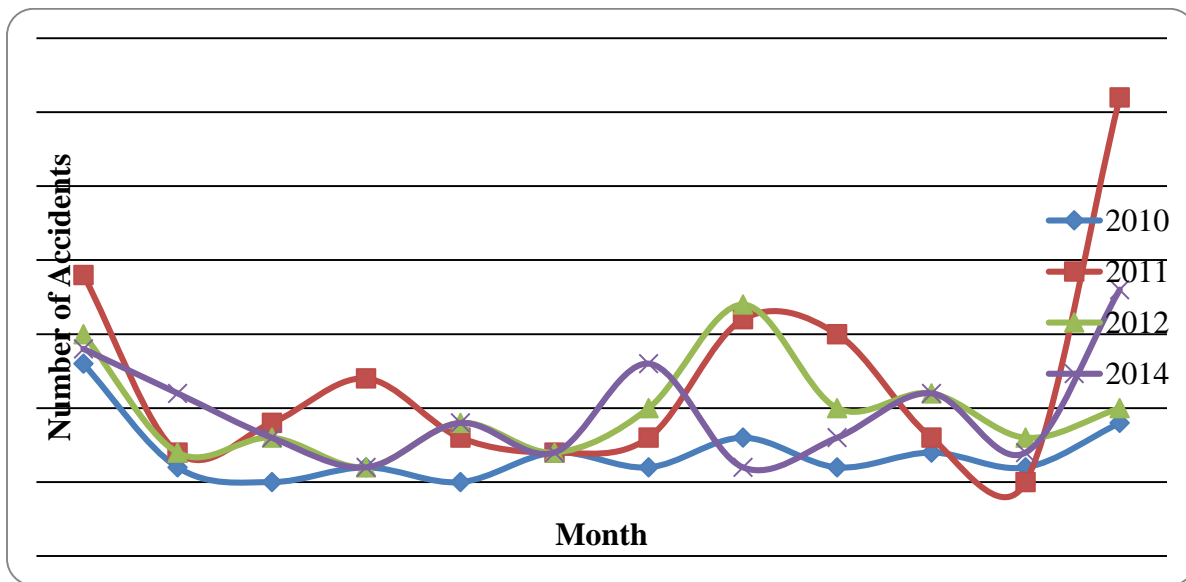
**Table 2: Road Traffic Accident Variation along the Routes**

Route	Year	No of Accidents	Percent (%)
Kaduna-Abuja	2010	24	10.6
	2011	84	37.8
	2012	57	25.8
	2014	57	25.8
	<b>Total</b>	<b>222</b>	<b>100.0</b>
Kaduna- Birnin Gwari	2010	18	16.0
	2011	54	47.2
	2012	27	23.6
	2014	15	13.2
	<b>Total</b>	<b>114</b>	<b>100.0</b>

Source: Authors Analysis from FRSC Records, 2017

### Monthly Variation of Road Traffic Accident along Kaduna-Abuja Road

Figure 4 indicates that the highest number of accidents for the year 2010 along Kaduna-Abuja road were recorded in the month of January, followed by December. This is similar to year 2014 where the months of December and January had the highest number of cases of road traffic accidents. This suggests that there was high occurrence of RTAs in the months of January and December in the area. The festivities associated with the period might be the possible explanation for the findings. This finding disagrees with Atubi (2012) that the month of July recorded the highest number of accidents which accounted for about 27% of all the road traffic accidents recorded in the selected Local Government Areas of Lagos State.

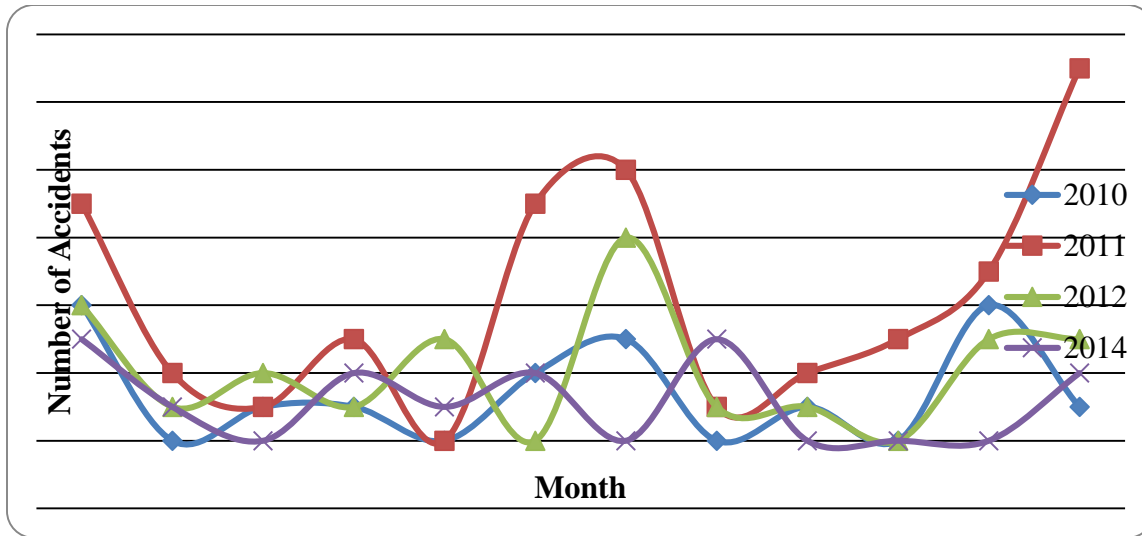


**Figure 4: Road Traffic Accident Monthly Variation along Kaduna-Abuja Road**

Source: Authors Analysis from FRSC Records, 2017

### Monthly Variation of Road Traffic Accident along Kaduna-Birnin Gwari Road

Figure 5 reveals that the highest frequency of accidents were recorded in the months of January and November for the year 2010 along Kaduna-Birnin Gwari as against December, July and May for the year 2011. Also in the year 2012, the months of July and January recorded the highest cases of accident with the least recorded in June and October. Consequently, the months of (January, July, November and December) recorded relatively high number of road traffic accidents thus rate among the most unsafe months along the study route. This result is similar with the occurrence of RTAs along Kaduna-Abuja road.



**Figure 5: Road Traffic Accident Monthly Variation along Kaduna-Birnin Gwari Road**  
 Source: Authors Analysis from FRSC Records, 2017

**Spatial Pattern of Road Traffic Accidents**

Table 3 shows that the nearest neighbour index for Kaduna-Abuja is 0.135346 while that of Kaduna-Birnin Gwari route is 0.229775 with z-scores of -23.970816 and -15.170547 respectively. According to Clark and Evans (1954), if the index (average nearest neighbour ratio) is less than 1, the pattern exhibits clustering. If the index is greater than 1, the pattern is toward dispersion. The nearest neighbour indexes show a clustered pattern of road traffic accidents distribution along the two routes. The clustered pattern indicates an uneven distribution of the RTAs over space along the study routes. This result corroborates the findings of Rukewe et al. (2014) that the pattern of road traffic crashes in Ibadan metropolis were generally clustered in space and localized.

**Table 3: Spatial Pattern of Road Traffic Accidents**

	Kaduna-Abuja	Kaduna-Birnin Gwari
Observed Mean Distance	134.55 Meters	313.53 Meters
Expected Mean Distance	994.11 Meters	1364.51 Meters
Nearest Neighbour Ratio	0.135346	0.229775
z-score	-23.970816	-15.170547
p-value	0.0000000	0.0000000

Source: Authors Analysis, 2017



## CONCLUSION

Road traffic accidents as one of the leading cause of death along major highways in Kaduna State vary with time and often follow a pattern. Therefore, its occurrence changes continually with time and space. The result shows that there exist spatial and temporal variations of road traffic accidents along the major highways in Kaduna State. Clearly indicated was yearly variation of the number of road traffic accidents along the highways which occurred mostly during the festive periods. Accidents locations along the major highways in Kaduna State were found to be clustered at certain locations. It is recommended that there should be strict enforcement of safety measures like drivers' use of speed limit devices among others and public education programme by FRSC on road safety during festive periods.

## REFERENCES

- Agbeboh, G.U. and Osarumwense, O. (2013). Empirical Analysis of Road Traffic Accidents: A Case Study of Kogi State, North-Central Nigeria. *International Journal of Physical Sciences*. 8(40), 1923-1933
- Atubi, A.O. (2012). Determinants of Road Traffic Accidents in Lagos State: Some Lessons for Nigeria. *International Journal of Humanities and Social Sciences*. 73-82
- Balogun, S.A. (2013). Modeling Road Traffic Crash in Abuja with GIS and Remote Sensing Technology, Paper Presented at Olabisi Olabanjo University, during *Workshop on R/S and GIS*, National Development and Security
- Barbour, K.M. (1982). *Nigeria in Maps Hodder and Shoughton Hong Long*.
- Bolade, T. and Ogunsanya, A. A. (eds) (1991). Accident Control Central Bank of Nigeria (1997) Annual Report and Statement of Account for the Year Ended 31st December, CBN, Abuja.
- Chaney, R. A. and Kim, C. (2014). Characterizing Bicycle Collisions by Neighbourhood in a Large Midwestern City. *Health Promotion Practice*. 15(2), 232-242.
- Clark, P.J. and Evans, F.C (1954). Distance to Nearest Neighbor as a Measure of Spatial Relationship in Populations, *Ecology*. 35, 445-453
- Erdogan, S., Yilmaz, I., Baybura, T., and Gullu, M. (2008). Geographical Information Systems Aided Traffic Accident Analysis System Case Study: City of Afyonkarahisar. *Accident Analysis and Prevention*. 40(1), 174-181.
- Federal Road Safety Corps (2017). *FRSC Annual Report 2016*. Federal Road Safety Corps (FRSC), Nigeria.

- Gao, D., Li, X., Yang, C. and Zhang, Y. (2012). Spatial Patterns Analysis of Urban Road Traffic Accidents based on GIS. Paper presented at the IET Conference Publications, 2012 (598 CP). 1898-1901
- International Transport Forum [ITF] (2014). *Road Safety Annual Report 2014*, OECD Publishing, Paris
- Kual, A., Sinha, V.S., Pathak, Y.K., Singh, A., Kopoor, A.K., Sharma, S., and Singh, S. (2005). Fatal Road Traffic Accidents, Study of Distribution, Nature and Type of Injury, *JIAFM*. 27(2):71-78.
- National Population Commission (2009). National Population Census 2006. Federal Government of Nigeria
- OSGOF (2011). Kaduna Street Guide. *Office of Surveyor General of the Federation*. 2011 Edition Barbour, 1982).
- Parkman International Association (1997). State Wide Water Resources Master Plan, Kaduna *State Water Resources and Facilities*. 2, 22-23
- Rukewe, A., Taiwo, O.J., Fatiregun, A.A., Afuwape, O.O. and Alonge, T.O. (2014). Geographic Information Systems in Determining Road Traffic Crash Analysis in Ibadan, Nigeria. *Journal of the West African College of Surgeons*. 4(3): 20-34
- Schwela, D. (2008). *Urban Traffic Management and Implications*. Routledge, New York, USA
- Shamsuddin, S., Anil, M., Othman, C.P., Sitti, A. and Tarmizi, I. (2015). Spatial and Temporal Pattern of Road Accidents and Casualties in Peninsular Malaysia. *Jurnal Teknologi Sciences & Engineering*. 14, 57–65
- Steenberghen, T., Thomas, I., Dufays, T. and B. Flahaut (2004), Intra-urban Location and Clustering of Road Accidents using GIS: A Belgian Example. *International Journal of Geographical Information Science*. 18, 169–181
- World Bank (1999). *The World Bank Annual Report 1999*. Washington DC: World Bank
- World Health Organization [WHO] (2004). World Report on Road Traffic Injury Prevention: Summary. World Health Organization, Geneva Switzerland
- Zhang, Y., Bigham, J., Ragland, D. and Chen, X. (2015). Investigating the Associations Between Road Network Structure and Non-Motorist Accidents. *Journal of Transport Geography*. 42: 34-47