

GEO-SPATIAL ANALYSIS OF ROAD TRAFFIC ACCIDENTS DISTRIBUTION ALONG ABUJA-KADUNA HIGHWAY, NIGERIA

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Abstract

This study conducted a geo-spatial analysis of road traffic accidents distribution along Abuja-Kaduna highway, Nigeria. The study used road traffic accident records between years 2013 to 2018 from Federal Road Safety Corps and google earth satellite imagery. Handheld GPS was used to acquire the absolute location of road traffic accidents. Descriptive statistics and Average Nearest Neighbour statistical tool in ArcGIS 10.1 were used to analyze the data. The result revealed that 71.5% of the total number of recorded road traffic accidents during the entire study period (2013-2018) occurred along Kaduna-Abuja while Abuja-Kaduna had only 28.5%. There was a yearly percentage increase in the number of road traffic accidents recorded along Abuja-Kaduna while a percentage decrease was observed along Kaduna-Abuja. Regarding the spatial pattern, it was found that the distribution of road traffic accidents in the entire study period had a cluster pattern in both Abuja-Kaduna and Kaduna-Abuja roads which was statistically significant. The findings showed that of 16,724 persons involved in road traffic accidents along the study route, about 73% were recorded along Kaduna-Abuja while Abuja-Kaduna had only 27%. Almost 73% of the number of persons injured due to RTAs were recorded along Kaduna-Abuja. A total of 1,437 persons lost their lives due to 2,179 RTAs which the distribution shows that 69% of the number of lives lost occurred along Kaduna-Abuja. Factors that caused RTAs were mainly attributed to speed violation, tyre burst, loss of control and dangerous driving. Strict enforcement of safety measures like drivers' use of speed limit devices among others and public education programme by FRSC on road safety were recommended.

Keywords: Abuja-Kaduna Highway, Nearest Neighbour Ratio, Road Traffic Accident, Spatial Pattern, Temporal Variation

Introduction

Road transport is obvious the most common mode of transportation. Road transport's major advantage compared with others is its elasticity, which permits it to function from door-to-door over short distances at the most competitive prices (Wough, 1990). In Africa over 80% of the inter-urban freight and passenger movements is done by road (Kindaya, 2014). According to Ogunsanya (2002) the high incidence of road accident tends to easily erode the positive effect of road transport in the nation's economy hence transport is described as the "maker and breaker" of the cities. Road Traffic Accidents [RTAs] have become common in every day urban life.

According to Rune and Truls (2004), road traffic accident is any vehicular accident occurring on a public highway which includes collisions between vehicles and vehicles, vehicles and animals,

vehicles and pedestrians or vehicle and fixed obstacles. Astrom, Kent and Jovi (2006) stated that road traffic accident is a collision or similar incident involving a moving vehicle, resulting in property damage, personal injury or death. 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. RTA may be fatal, resulting in deaths of the road users, passengers, drivers or pedestrians, or minor when it is not severe enough as to cause substantial hardship (Sarin, 2000).

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). Kopits (2005) posited that currently motor vehicle accidents rank 9th in order of disease burden and are projected to rank 3rd in the year 2020 globally. The same document estimated that in Africa; 59,000 people lost their lives in road crashes in 1990 and this figure has been estimated to be 144,000 people by 2020. According to Federal Road Safety Corps [FRSC] Annual Report (2013) in the year 2012, out of 14,783 cases of road traffic crashes, 6,573 persons were reported killed while 40,683 people were injured. Despite the slight drop from the previous years in 2013, the problem still persists and this calls for serious intervention. FRSC Report (2017) stated that in the year 2016, 9,694 road traffic crashes were recorded out of which 2,638 cases were fatal, 5,633 were serious cases and 1,423 cases were minor and out of the total figure for the accidents 5,053 persons were killed which indicate a decrease in number of crashes by 0.4% and fatalities by 7% compared to the figures of 2015 with 9,734 crashes and 5,440 deaths. This clearly demonstrates that road traffic deaths trend has not been reversed in line with the United Nation decade of action 2011-2020 goal to stabilize and reduce the forecast level of road traffic deaths around the world.

According to Ansari, Akhdar, Mandoorah, and Moutaery (2000) the causes of RTAs can be fairly grouped as general and specific. The general causes include increase in number of vehicles and expansion of transport network, while specific causes are driver error, excess speed, poor cognizance of road signs and road conditions. However, the causes of RTAs from most countries can be summarized to include driver behaviour, vehicle types, roadway condition (design, capacity, pavement type), traffic characteristics (flow, speed, density, occupancy), and environmental factors such as weather (Li, Zhu and Sui, 2007; Pepple and Adio, 2014). Eze (2013) stated that road traffic accidents can be caused by a combination of these factors.

The incidence of road accidents and fatalities vary at both spatial and temporal scales (World Bank, 1999). According to FRSC (2017) report Abuja-Kaduna, Kaduna-Zaria, Oyo-Ogbomosho and Doka-Kaduna roads recorded relatively high number of deaths of 108, 102, 97 and 69 respectively in the year 2016. This high fatality rate due to RTAs along Abuja-Kaduna highway has become worrisome and a source of concern to everyone especially its negative effects on the socio-economic development of the settlements along the road. More so, from a public health perspective, the road traffic fatalities have become increasingly more significant among overall fatalities and are affecting mainly the most vulnerable users. Hence, the need to analyze road traffic accidents along Abuja-Kaduna highway which is the thrust of this study.

Materials and Method

Study Area

Abuja-Kaduna highway is one of the busiest roads in Northern Nigeria. It connects most of the North-Western and North-Eastern States to the Federal Capital Territory [FCT], Abuja of Nigeria.

It is situated between Latitudes 9° 20' and 10° 20' N of the Equator and Longitudes 6° 20' and 8° 00' E of the Greenwich Meridian. It begins from Abuja Junction in Kaduna state and ends at Zuba in FCT, Abuja covering total length of approximately 175km (Figure 1). There are many economic activities going on along the Abuja-Kaduna highway. The settlements located at both sides of the road do engage in a lot of agricultural activities. Among the food crops grown are maize, guinea corn, yam while sugarcane as a cash crop of great importance was also grown. Numerous petty trading activities and hawking of item are going on both sides of the express road.

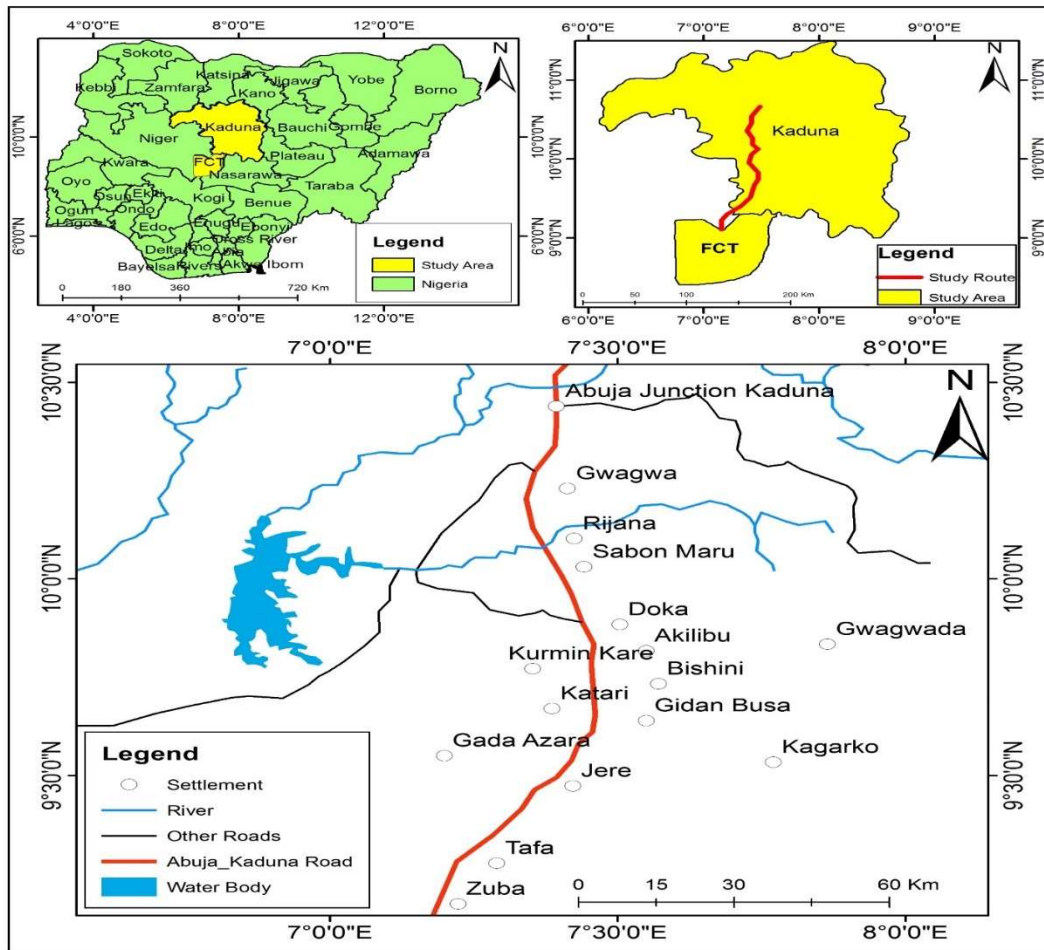


Figure 1: Abuja-Kaduna Highway (The Study Route).

Source: Google Earth, (2015)

Methods

Road traffic accident records between years 2013 to 2018 along Abuja-Kaduna highway were obtained from of the Federal Road Safety Commission. The absolute location of road traffic accident along the highway was acquired using a handheld GPS receiver during the field survey. The geographic coordinates of road traffic accidents locations were overlaid in ArcGIS environment on the geo-referenced and digitized road network map from the google earth satellite imagery in order to show the distribution of RTA. 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. Descriptive statistics was used to examine the periods of road traffic accidents and the characteristics as extracted from the FRSC road traffic accidents record.

Results and Discussion

Distribution of Road Traffic Accident Occurrence During the Study Period

Table 1 revealed that 71.5% of the total number of recorded road traffic accidents during the entire study period (2013-2018) occurred along Kaduna-Abuja carriage way while Abuja-Kaduna carriage way had only 28.5%. This is an indication of uneven distribution of road traffic accidents on different carriage way along a particular road as more road traffic accidents tend to occur on one carriage way more than the other. This result partly corroborates Lawal, Okere, and Akpu, (2018) study that established spatial variation in road traffic accidents along Kaduna-Abuja and Kaduna-Birnin Gwari highways in Kaduna state.

Table 1: Distribution of Road Traffic Accident Occurrence

Carriage Way	No. of RTA	Percentage
Abuja-Kaduna	622	28.5
Kaduna-Abuja	1559	71.5
Total	2179	100

Source: Authors Analysis, 2021

Temporal Variation of Road Traffic Accident Occurrence (2013-2015)

As indicated in Table 2, a little above two third of the road traffic accidents recorded during the period (2013-2015) occurred along Kaduna-Abuja carriage way while Abuja-Kaduna had only 35%. Variation across the three-year period shows that Abuja-Kaduna recorded the highest number of road traffic accidents both in 2014 and 2015 with 55.7% and 58.6% respectively whereas in year 2013, Kaduna-Abuja carriage way had the highest recorded number of road traffic accidents with approximately 92% as against about 9% for Abuja-Kaduna carriage. Yearly percentage increase in the number of road traffic accidents recorded was noticed along Abuja-Kaduna carriage way while a yearly percentage decrease was observed along Kaduna-Abuja with year 2013 having the highest. Figure 2 and 3 depicts the diagrammatical representation of the distribution of RTAs along the study route for the period.

Table 2: Distribution of Road Traffic Accident Occurrence (2013-2015)

Carriage Way	2013		2014		2015		Total	
	No. of RTA	%	No. of RTA	%	No. of RTA	%	No. of RTA	%
Abuja-Kaduna	32	8.5	118	55.7	140	58.6	290	35.0
Kaduna-Abuja	346	91.5	94	44.3	99	41.4	539	65.0
Total	378	100	212	100	239	100	829	100

Source: Authors Analysis, 2021

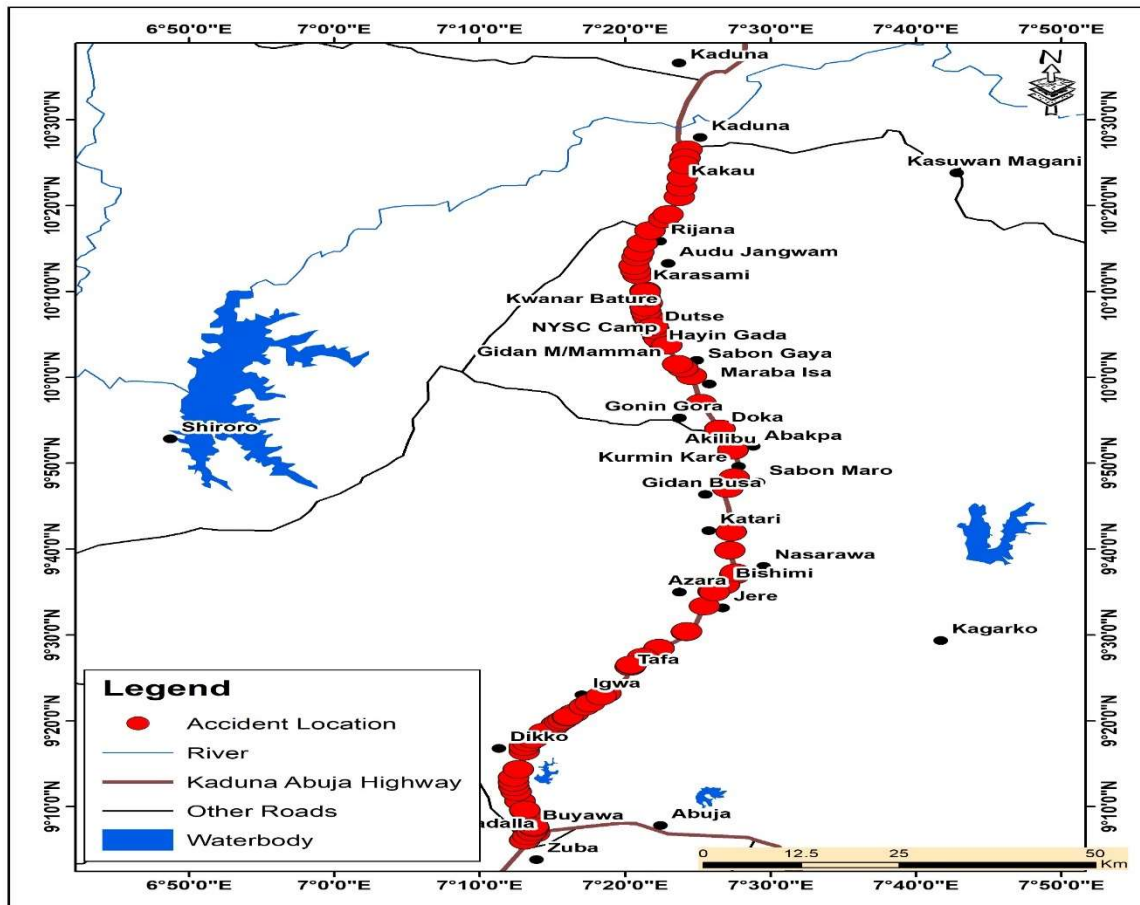


Figure 2: Distribution of Road Traffic Accidents along Abuja-Kaduna (2013-2015)

Source: Authors GIS Analysis, 2021

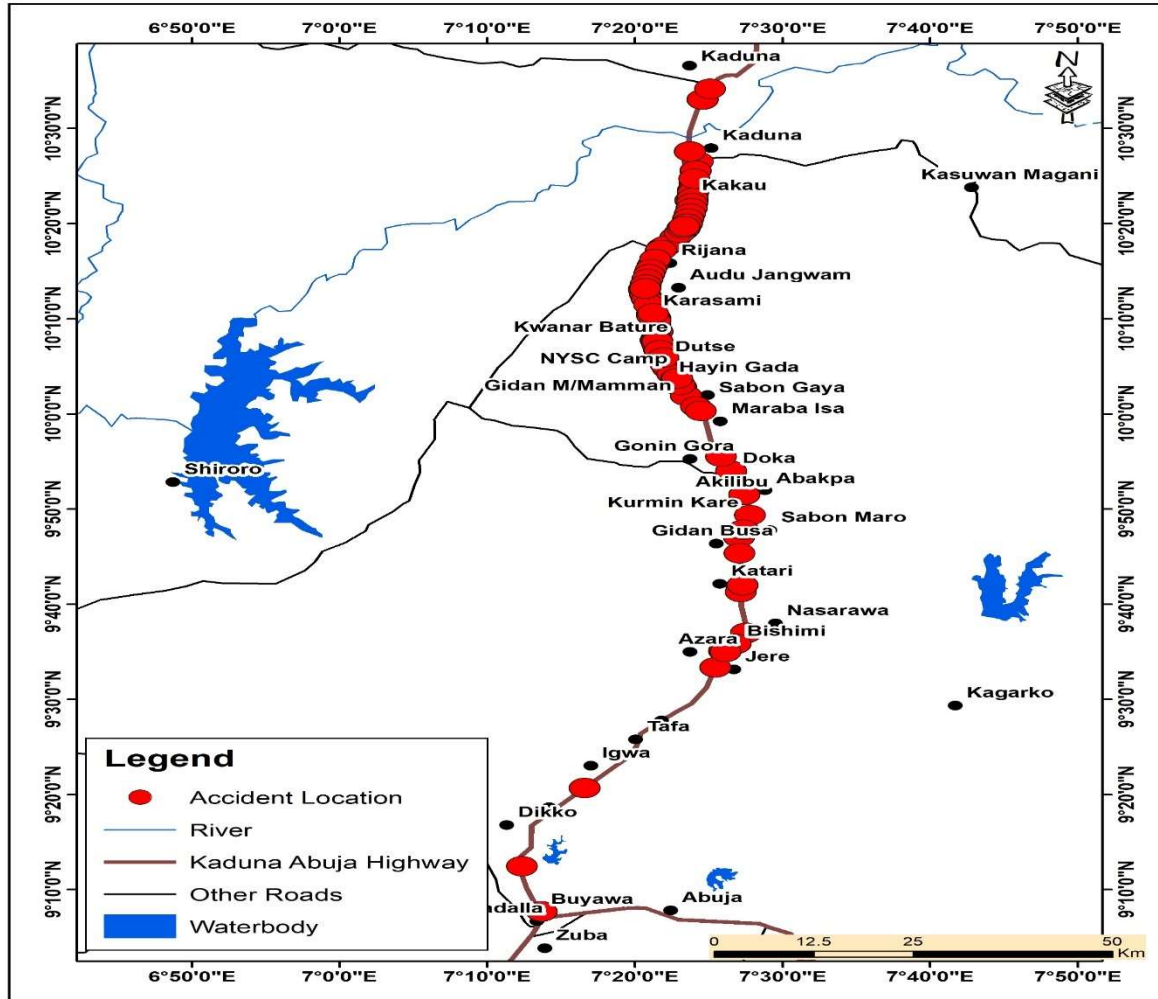


Figure 3: Distribution of Road Traffic Accidents along Kaduna-Abuja (2013-2015)

Source: Authors GIS Analysis, 2021

Temporal Variation of Road Traffic Accident Occurrence (2016-2018)

Table 3 revealed that 75% of the total recorded number of road traffic accidents occurred along Kaduna-Abuja carriage way. The result further shows that Kaduna-Abuja carriage way recorded a greater number of road traffic accidents in each of the year when compared with Abuja-Kaduna carriage way. Also, observable was a yearly percentage increase from 54% in the number of recorded road traffic accidents in 2016 along Kaduna-Abuja carriage way to 84% in 2017 with a slight drop to approximately 82%. It is clear from this result that the occurrence of road traffic accidents along Kaduna-Abuja carriage way are on the increase. This result is consistent with the findings of Lawal (2017) that established temporal variation in road traffic accidents along Kaduna-Abuja and Kaduna-Birnin Gwari highways in Kaduna state. On the other hand, yearly percentage decrease was obvious along Abuja-Kaduna carriage way although with a slight increase in year 2018. The fluctuation in the yearly percentage trend of RTAs is an indication of the need to learn from the developed countries on how significant consistent success has been achieved in tackling their road safety problems. Ibitoye (2008) asserts that developed nations have involved both the elimination of the most hazardous location and safety conscious planning

and design to improve traffic safety on their road network. Figure 4 and 5 show the distribution of RTAs along the study route for the period.

Table 3: Distribution of Road Traffic Accident Occurrence (2016-2018)

Carriage Way	2016		2017		2018		Total	
	No. of RTA	%	No. of RTA	%	No. of RTA	%	No. of RTA	%
Abuja-Kaduna	160	46.4	82	16.0	90	18.2	332	24.6
Kaduna-Abuja	185	53.6	429	84.0	404	81.8	1018	75.4
Total	345	100	511	100	494	100	1350	100

Source: Authors Analysis, 2021

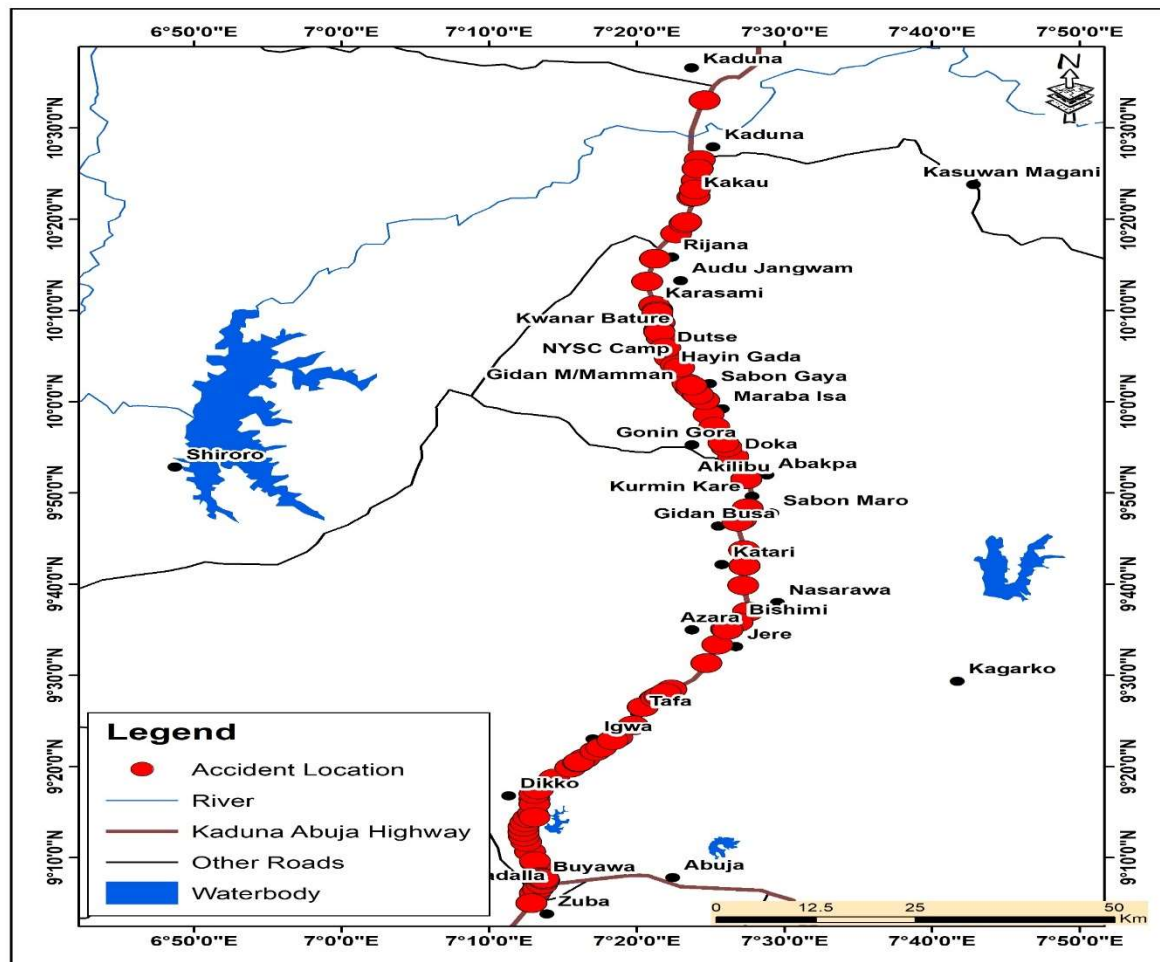


Figure 4: Distribution of Road Traffic Accidents along Abuja-Kaduna (2016-2018)

Source: Authors GIS Analysis, 2021

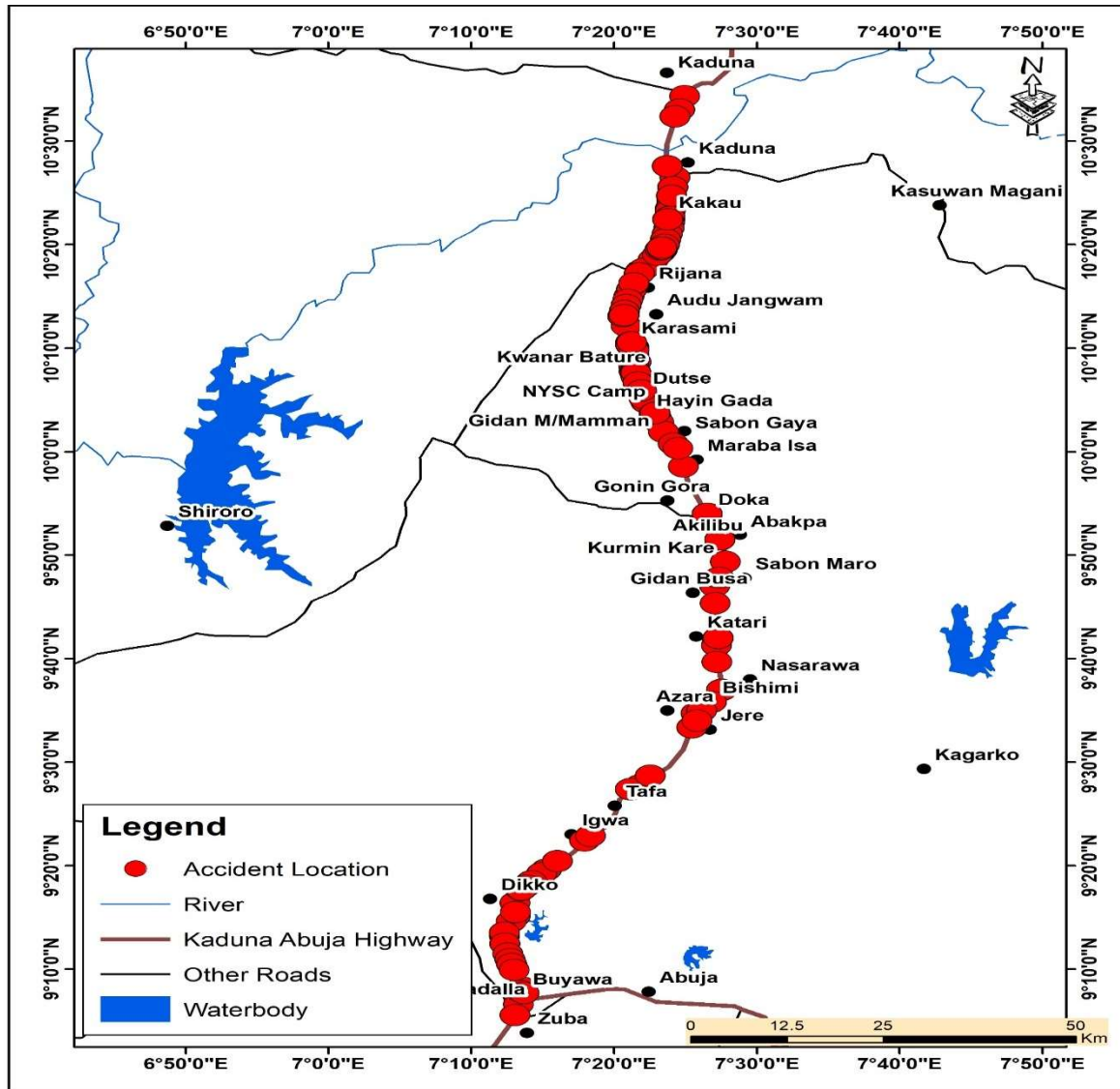


Figure 5: Distribution of Road Traffic Accidents along Kaduna-Abuja (2016-2018)

Source: Authors GIS Analysis, 2021

Spatial Pattern of Road Traffic Accidents along Abuja-Kaduna Highway

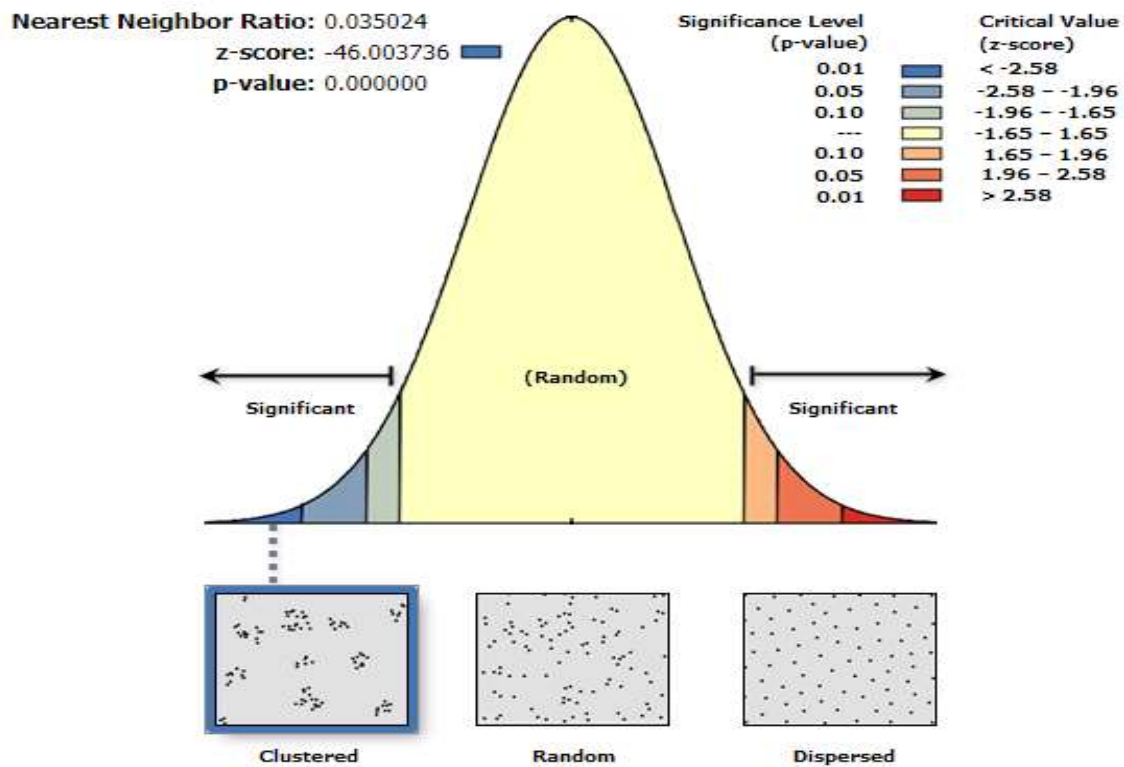
The pattern of the distribution of road traffic accident determined using the Average Nearest Neighbour in spatial statistic toolbox of ArcGIS version 10.1 environment. The average nearest neighbour analyses calculates the nearest neighbour index (which is a measure of the distance between each accident 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. Table 4 shows the Nearest Neighbor Ratio (Rn), z-score and p-value.

Table 4: Spatial Pattern of Road Traffic Accidents along Abuja-Kaduna Highway

	Abuja-Kaduna	Kaduna-Abuja
Observed Mean Distance	41.837 meters	191.470 meters
Expected Mean Distance	1194.510 meters	2758.465 meters
Nearest Neighbour Ratio	0.035	0.069
z-score	-46.004	-70.270
p-value	0.000	0.000

Source: Author GIS Analysis, 2021

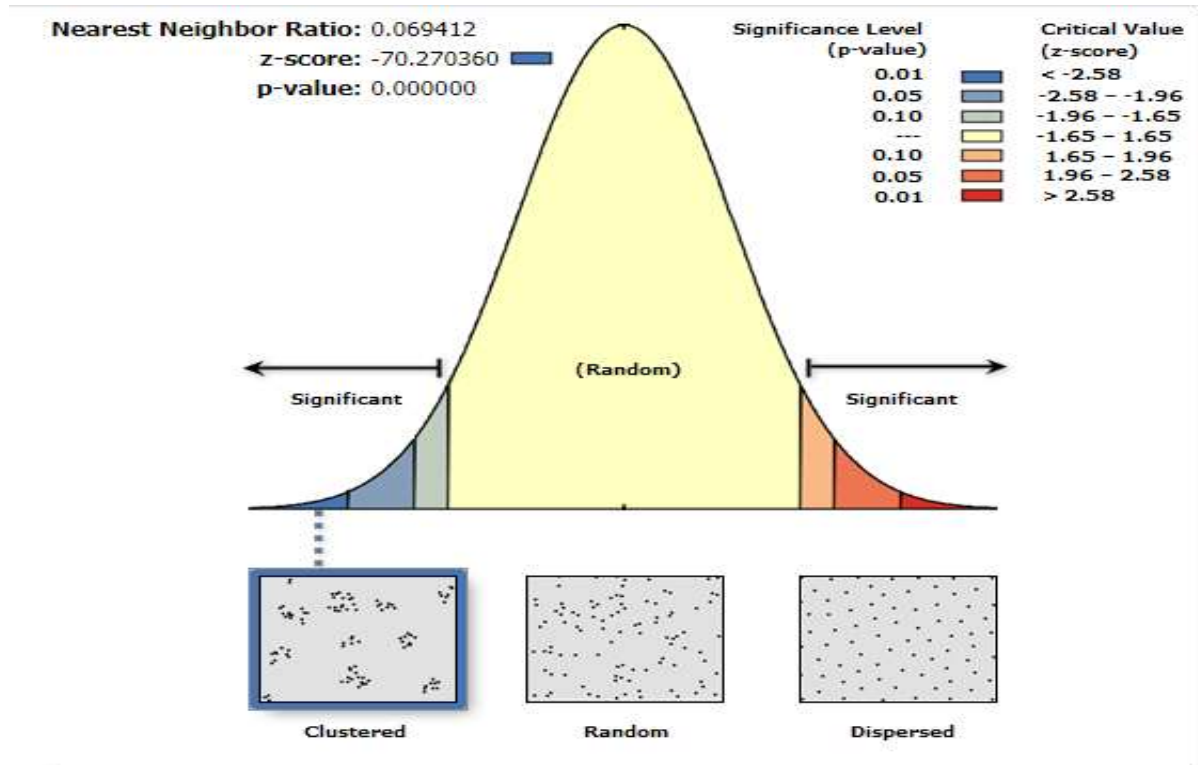
Table 4 shows that nearest neighbour ratio for Abuja-Kaduna is 0.035 and for Kaduna-Abuja route is 0.069 with z-score of -46.004 and -70.270 respectively. Based on Clark and Evans (1954) classification; if the nearest neighbour ratio is less than 1, the pattern exhibits clustering and when greater than 1, the pattern is toward dispersion. Consequently, the result shows that road traffic accidents have a cluster pattern in Abuja-Kaduna and Kaduna-Abuja (Figure 6 and 7). The cluster pattern along the both roads were found to be significant given that the p-values were less than 0.05.



Given the z-score of -46.0037363171, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Figure 6: Spatial Pattern of Accidents along Abuja-Kaduna Carriage Way

Source: Authors GIS Analysis, 2021



Given the z-score of -70.2703601048, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Figure 7: Spatial Pattern of Accidents along Kaduna-Abuja Carriage Way

Source: Authors GIS Analysis, 2021

However, in comparison RTAs tend to be more clustered along Abuja-Kaduna carriage way than Kaduna-Abuja carriage way. This implies that RTAs occur more at specific locations along Abuja-Kaduna road as such might have fewer RTAs locations when compared with Kaduna-Abuja road. This result agrees with the findings of Rukewe, Taiwo, Fatiregun, Afuwape and Alonge (2014) that the pattern of road traffic crashes in Ibadan Metropolis were generally clustered in space and localized in the metropolis. Similarly, Lawal, Okere, and Akpu, (2018) study finding established a clustered pattern of road traffic accidents distribution along Kaduna-Abuja and Kaduna-Birnin Gwari highways respectively.

Characteristics of Road Traffic Accidents along Abuja-Kaduna Highway

The characteristics of road traffic accidents such as reported number of persons involved in road traffic accident, number of persons injured and lives lost to accidents as extracted from FRSC road traffic accident record in the area were discussed. Also, the causes of road traffic accidents were examined.

Number of Persons Involved in Road Traffic Accidents along Abuja-Kaduna Highway

Table 5 reveals that of 16,724 persons involved in road traffic accidents along the study route, about 73% were recorded along Kaduna-Abuja road while Abuja-Kaduna road had only 27%. This is an indication that in spite of all proactive and reactive measures by government agencies such as FRSC among others, the number of persons involved in road traffic accidents along the study

route is still reported to be significantly high, indicating the need of more proactive measures to lessen the numbers of persons involved in road traffic accidents.

Table 5: Distribution of Number of Persons Involved in Road Traffic Accidents

Carriage Way	No. of Persons	Percentage
Abuja-Kaduna	4,482	26.8
Kaduna-Abuja	12,242	73.2
Total	16,724	100

Source: Authors Analysis, 2021

Injury Due to Road Traffic Accidents along Abuja-Kaduna Highway

Table 6 revealed that of all the number of persons injured due to RTAs, almost three-fourths (73%) were recorded along Kaduna-Abuja road. This shows the contribution of RTAs to injuries which according to Nkwonta (2013 cited in Olusina and Ajanaku, 2017) road traffic injuries have become a major cause of morbidity and mortality worldwide, but especially in low-and-middle income countries. The increase in the number of injuries due to RTAs as revealed in this study could be attributed to lack of appropriate safety infrastructure along most Nigerian roads and emergency numbers to call when an injury event occurs. It has been proven that road traffic injuries cause significant economic losses to individuals, their families and the society at large and these losses may be associated with cost of treatment, loss of productivity and valuable working time for victims and relatives, loss of skilled labour force, and loss of school hours. Pratte (1998) estimated that persons injured in accidents on Nigerian highways and streets no longer participate in the economic mainstream and this amounts to a loss of labour of millions of person's years to the nation. Apart from the economic losses, is the social cost such as pain, grief and suffering associated with the RTAs injuries.

Table 6: Distribution of Number of Persons Injured in Road Traffic Accidents

Carriage Way	No. of Persons	Percentage
Abuja-Kaduna	2,248	27.5
Kaduna-Abuja	5,920	72.5
Total	8,168	100

Source: Authors Analysis, 2021

Life Lost in Road Traffic Accidents along Abuja-Kaduna Highway

A total of 1,437 persons lost their lives due to 2,179 RTAs recorded during the study period under consideration along the road (Table 7). The distribution shows that 69% of the number of lives lost as a result of RTAs occurred along Kaduna-Abuja road. This shows that road traffic accident along the study route is fast becoming a major killer of people, most importantly, the active population as such deliberate measures are required to be put in place at all level to prevent this negative incident.

Table 7: Distribution of Number of Lives Lost in Road Traffic Accidents

Carriage Way	No. of Persons	Percentage
Abuja-Kaduna	446	31.0
Kaduna-Abuja	991	69.0
Total	1,437	100

Source: Authors Analysis, 2021

Causes of Road Traffic Accidents along Abuja-Kaduna Highway

To develop strategies to prevent or reducing road traffic accidents, there is an imperative need to understand the causes of RTAs. Table 8 indicated that the causes of RTAs were multi-factorial but were mainly attributed to speed violation, tyre burst, loss of control and dangerous driving. It is not uncommon that human or driver factors (speed violation, loss of control and dangerous driving) and vehicular fault (tire burst) caused a greater percentage of RTAs. This finding is similar with Lum and Reagan (1995) that driver factors solely contributes to about 57% of road traffic accidents and 93% either alone or in combination with other factors in Washington D.C and in the study of Bun (2012), driver factors solely contributed to about 57% of road traffic accidents and 43% either alone or in combination with other factors in Nigeria.

Table 8: Causes of Road Traffic Accidents along Abuja-Kaduna Highway

Cause	No. of RTAs	Percentage
Brake Failure (BFL)	9	0.41
Bad Road (BRD)	12	0.55
Driving under Alcohol/Drug Influence (DAD)	8	0.37
Dangerous Driving (DGD)	170	7.80
Dangerous Overtaking (DOT, DOV)	43	1.98
Fatigue (FTQ)	9	0.41
Loss of Control (LOC)	193	8.86
Mechanically Deficient Vehicle (MDV)	92	4.22
Road Obstruction Violation (OBS, ROB)	51	2.34
Overloading (OVL)	6	0.28
Poor Weather (PWR)	1	0.05
Army Robbery	7	0.32
Route Violation (ROV, RTV)	69	3.17
Speed Violation (SLV, SPV)	1209	55.48
Tire Burst (TBT)	232	10.65
Use of Phone While Driving (UPD, UPWD)	3	0.14
Wrongful Overtaking (WOT, WOV)	43	1.97
Others (Hit and Run, Sharp Bend, etc.)	11	0.50
Nil	11	0.50
Total	2179	100

Source: Authors Analysis, 2021

The risk of RTA occurring increases exponentially with driver speeding much faster than the average speed. More so, tyre burst as a cause of RTAs could be attributed to the fact that most vehicles used on Nigerian roads with their tyres are fairly used and have been used for over 15 years in Nigeria as stated by Ohakwe, Iwueze and Chikezie (2011). It is believed that a well-maintained vehicle; tyres are good and the suspension well-adjusted is less likely to be involved in RTAs and the vehicle is more controllable in an emergency and thus better equipped to avoid

RTAs. Generally, this finding agrees with AUSTROADS (1994) which stated that one or more of human, vehicle, road and environmental factors must be involved for RTA to occur. Thus, the causes of road traffic accidents are multi-factorial. On the other hand, the use of mobile phones while driving and poor weather conditions were least frequently recorded factors that contributed to occurrence of RTAs along the study highway.

Conclusion

The study established the spatial and temporal variations of road traffic accidents along Abuja-Kaduna highway. Road traffic accident was identified as one of the leading causes of deaths along Abuja-Kaduna highway. Clearly indicated was yearly variation of the number of road traffic accidents along the highway. The accidents locations were found to be clustered at certain locations. The study as well established the multi-factorial nature in the causes of road traffic accidents. The study recommended that the Federal Road Safety Corps (FRSC) and Police along Abuja-Kaduna highway should enforce drivers' use of speed limit devices inside vehicles such as seat belt among others and public education programme on speed should be adopted and mounted along Abuja-Kaduna highway.

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