ANALYSIS OF CAUSES AND EFFECTS OF ROAD TRANSPORT ACCIDENTS ALONG ZARIA-SOBA ROAD KADUNA STATE, NIGERIA

Olutoyin Moses Adedokun[1]*, Aduke Olufunmilayo Bello[2], Rifkatu Dyaji[3], Angela Uwanuakwa[4] & Abdulhadi Aliyu[5]

[1-5]Department of Geography, Federal University of Education, Zaria

*toyinadedoun@gmail.com

ABSTRACT

This work examines the locations, causes and effects of road traffic accidents along the Zaria-Soba highway in Kaduna State, Nigeria. The data used for the study were obtained from people along the route. Using simple random sampling, questionnaires were administered to the respondents. A total of 150 questionnaires were administered in ten selected villages along the route. Descriptive statistics, especially percentages and tables, were used to analyse the data. The results of the study showed that the major causal factor of accidents along the route is bad road, 58.7%, 22.7% was as a result of careless driving, 6.5% was due to overspeeding, drunkenness accounts for 3.3%, lack of regard for road signs due to illiteracy account for 2.0%. It was also discovered that 35% of the accidents occurred between 1.00 pm and 4.00 pm, 26.5% occurred mostly at night (5-10 pm), and 13.5% occurred in the morning. It is, therefore, suggested that the government reconstruct the route or, in the short run, refill the potholes, especially in areas with high cases of accidents. Public awareness and traffic education, such as the use of seat belts, interpretation of road signs, regular vehicle checks, etc., should be carried out by the FRSC. Road infrastructure, such as road signs and pedestrian bridges that need to be improved along the study route, should be provided, with a view to making the Zaria- Soba route accident-free.

Abstract: Road Traffic Accidents, Zaria-Soba Highway, Causal Factors, Road Infrastructure, Traffic Safety Awareness

INTRODUCTION

Road transportation is by far the commonest means of transportation in Nigeria when compared to other modes like air, rail and water. In Nigeria, road accidents have been a disturbing phenomenon that has constituted a menace. It is generally believed but not statistically proven that the rate of road accidents in Nigeria has geometrically increased. Road accidents are caused by various reasons, ranging from carelessness on the part of the drivers to the deplorable nature of our roads. Put differently, Nigerian roads have become killing fields without protection for their users' making travellers heave a sigh of relief if they make it to their destinations (FRSC. 2004).

In developing countries like Nigeria, roads often carry a wide range of users, from heavy goods vehicles to bicycles and pedestrians, without any separation. Road traffic accidents (RTA) have become a significant, cause of many disabilities, death and economic loss. Every day many people are killed and injured on our roads.

To be precise, Zaria is a slightly heavily motorised city with poor road conditions and transport systems. It has a high rate of Road Traffic Accidents (RTAs), especially on the road leading to Soba from Zaria. The tendency is on the increase because Zaria is also connected to other important towns like Dutsen-wai, Pambeguwa, Saminaka, and Jos, the capital city of Plateau State.

The recognition of RTA as a crisis in Nigeria inspired the establishment of the Federal Road Safety Commission (FRSC). The FRSC was established by the government of the Federal Republic of Nigeria vide Decree 45 of 1988 as amended by Decree 35 of 1992, with effect from 18th February 1988. The Commission was charged with responsibilities for, among others, policymaking, organisation and administration of road safety in Nigeria. As can be seen from the trend over 15 years (1971-1985; Asogwa & Obionu, 1986), legislative and other countermeasures such as the establishment of FRSC and the Vehicle Inspection Officials (VIO) have not recorded spectacular achievement.

According to Odugbemi (2010), an accident is anything that happens by chance, anything that occurs unexpectedly and undesigned. A road traffic accident is a collision or similar incident involving a moving vehicle, resulting in property damage, personal injury or death (Astrom, Kent and Jovi, 2006). A road traffic accident is an unexpected phenomenon that occurs as a result of the use or operation of vehicles, including bicycles and handcarts, on public highways and roads. Accidents may be fatal, resulting in deaths of road users (passengers, drivers or pedestrians), or minor when it is not severe enough to cause substantial hardship (Sarin, 2000).

The RTAs can result in injury, property damage and death. RTA results in the deaths of 1.2 m people worldwide each year and injures about 4 times this number (WHO, 2004). In this study, a road traffic accident is defined as an accident which took place on the road between two or more objects, one of which must be any moving vehicle (Jha et al. 2004). Road Traffic Accidents (RTAs) are increasing at a rapid pace, and presently, these are one of the leading causes of death in developing countries. The morbidity and mortality burden in developing countries is rising due to a combination of factors, including rapid motorisation, poor road and traffic infrastructure as well as the behaviour of road users (Nantulya & Reich, 2002). This contrasts with technologically advanced countries where the indices are reducing (Oskam et al., 1994; O'Neill and Mohan, 2002).

The worrisome trend has a tremendous negative impact on the nation's health system as well as its social and economic aspirations. It was estimated that the total number of registered vehicles in Nigeria rose between 1990 – 2006 from 700,000 to 6,000,000 (Umar 2010). Despite the happiness this brought and the change in the quality of family lives associated with owning a vehicle, its possession has made so many families bereaved of their breadwinners or lovely ones due to the unprecedented rate of road traffic accidents in Nigeria. According to the Federal Road Safety Commission, not less than 88,520 road users lost their lives between 1991 and 2000 alone, most victims being between 20-40 years. There is a need to view road accidents as a very major issue requiring urgent attention aimed at preventing premature deaths and reducing the health, social and economic impacts it portends to the average Nigerian.

According to WHO (2016) report on Road Traffic accidents, about 1.25 million people die each year as a result of road traffic crashes. Road traffic crashes are the leading cause of death among people aged between 15 and 29 years. Currently, motor vehicle accidents rank 9th in order of disease burden and are projected to be ranked 3rd in the year 2020. In Africa, it has been estimated that 59,000 people lost their lives in road crashes in 1990 and this figure will

be 144,000 people by 2020, a 144 per cent increase (Kopits, 2005). Nearly three-quarters of deaths resulting from motor vehicle crashes occur in developing countries (Odero, 1998) and this problem appears to be increasing rapidly in these countries (Jacobs, Aeron-Thomas & Astrop, 2000). Apart from the humanitarian aspect of the problem, traffic accidents and injuries in these countries incur an annual loss of $65 billion to $100 billion annually. These costs include both loss of income and the burden placed on families to care for their injured relatives.

However, the probability of occurrence of road accidents and their severity can often be reduced by the application of proper traffic control devices and sound roadway design practices (Sarin, 2000). The success or failure of such control devices and design specifications, however, depends extensively upon the analysis of traffic accident records at specific locations. It has long been recognized that one of the effective means towards accident reduction lies in a systematic and scientific approach that is based on the use of accurate and reliable traffic accident data (Saxena et al. 2000).

Aim and objectives

The aim of this study is to identify the major locations, causes and effects of road traffic accidents along the Zaria – Soba highway with a view to providing a solution to the rate of occurrence of RTA along the route. This aim will be achieved through the following set of objectives:

   i.   Examine the causes of Road Traffic Accidents along the route.
   ii. Identify areas with high cases of road traffic accidents along the route.
   iii. Identify the effects of road accidents along the route.
   iv. Suggest ways of reducing accidents along the road.

Study area

The research covered two Local Government Areas in Kaduna state, (i.e. Zaria and Soba Local Government Areas.), The route from Zaria to Soba is about 45.54km from Kofan Doka, Zaria. The route is a single-carriage highway constructed by the Federal Government of Nigeria to link Zaria with Jos and other north-Eastern states such as Bauchi, Gombe and Borno states. Since its construction, the road has not been given any attention for maintenance (reconstruction) and has been damaged by constant use from motorists, e.g. tankers, lorries, cars and others. The damages imposed on the route have led to several road accidents, resulting in the loss of lives and properties. The road from Zaria to Soba has a number of settlements between them. The villages include: Nagoyi, M/Buzara, Dakace, Dambo, Sakaru, Maigana, T/Ice, U/Liman, Soba etc.
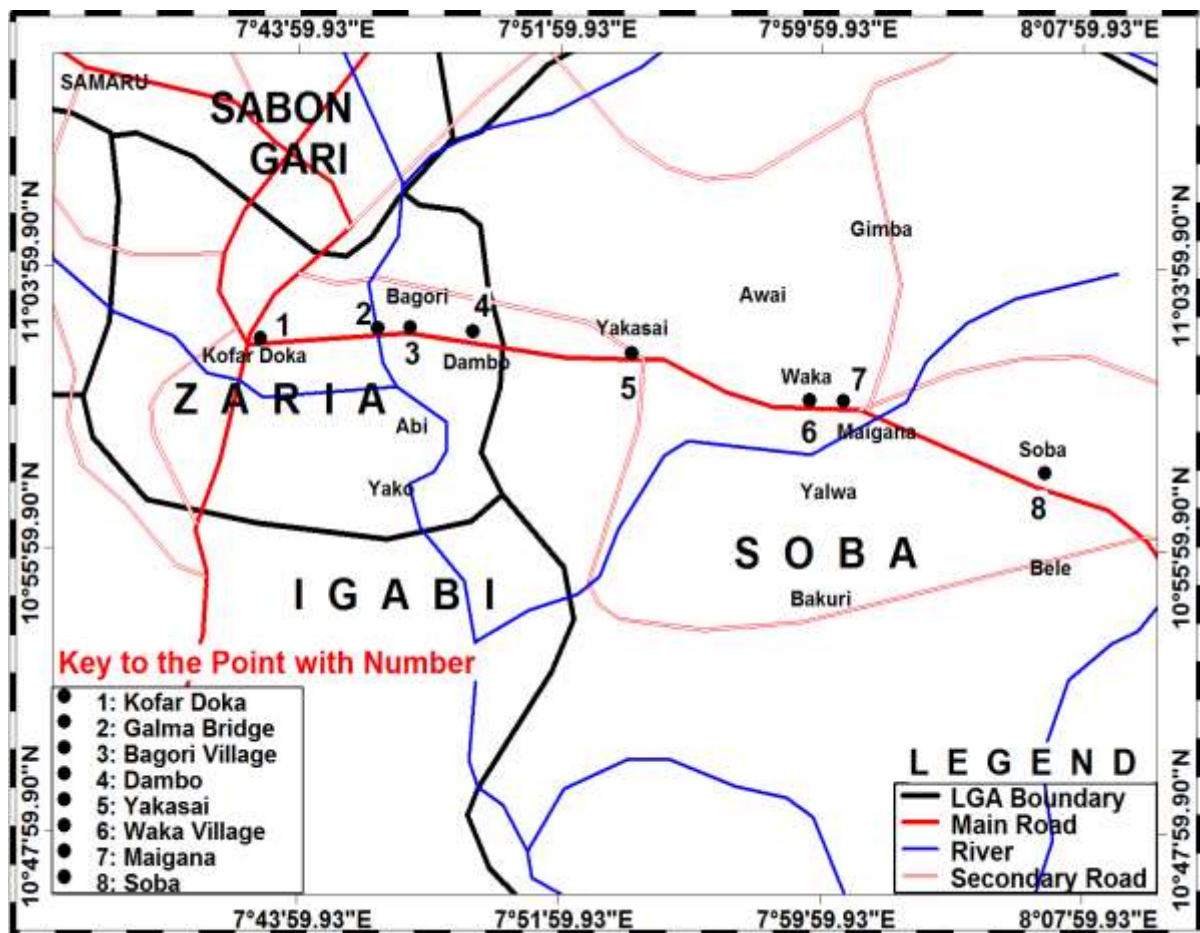
Fig. 1: Zaria & Soba LGAs Showing the Location of Points between Zaria to Soba Highway
Source: Geography Department Federal College of Education Zaria.

METHODOLOGY

Data collection and sampling method

The data used in this research was obtained from both primary and secondary data. The primary data consist of questionnaire, while the secondary data was from FRSC and NURTW.

Sampling Techniques

A systematic sampling technique was used in selecting the towns/locations along Zaria – Soba route. The questionnaire was administered using a simple random technique. A total of 150 questionnaires were administered to collect data from 10 towns selected towns were selected and 15 questionnaires was administered in each town to ensure proportionality.

Table 1: Settlements Along Zaria to Soba Road

S/N	NAMES OF TOWNS	SELECTED TOWNS
1	Pan-Zazzau	Pan Zazzau
2	Na Goyi/Unguwan Kaya	
3	Marabanbuzara	M/Buzara
4	Dakace	
5	Dambo	Dambo

6	Sakaru	
7	Yakasai	Yakasai
8	Wanka	
9	Tudunsaibu	T/Saibu
10	Maigana	
11	Tashan Ice	Tashan Ice
12	Unguwansako	
13	Yalwamai Bene	Yalwamai Bene
14	Tashanbakwalo	
15	Yalwamaimakaranta	YalwamaiMakaranta
16	Unguwan Liman	
17	Soba	Soba
18	Unguwandan-Isah	
20	Tashan Ice	Tashan Ice

Source: Fieldwork, 2018

Method of data analysis

The data collected was analysed using descriptive statistics such as frequency distribution, tables, percentages and charts.

DATA PRESENTATION AND ANALYSIS

Table 2: Gender of respondents

Gender	Frequency	(%)
Male	117	78
Female	33	22
Total	**150**	**100**

Source: Fieldwork, 2018

Table 2 shows that 78% were men while 22% were female.

Table 3: Age of the Respondent

Age	Frequency	(%)
18 -28	65	43.3
29 – 38	39	26
39 – 48	24	16
49 and above	22	14.7
Total	**150**	**100**

Source: Fieldwork, 2018

Table 3 shows that 43.3% are 18-28 years old, 26% are between 29- 38 years old, 16% are between 39-48 years old, and 14.7% are between 49 and above years old. This is a reliable result because the majority of road users are between 18 and 45 years old.

Table 4: Educational Level of the Respondents

Education	Frequency	(%)
Primary	62	41.3
Secondary	61	40.7
Tertiary	20	13.3
Others	7	4.7
Total	**150**	**100**

Source: Fieldwork, 2018

Table 6. shows that 41.3% stopped schooling at the primary level, 40.7% secondary, 13.3% tertiary, while 4.7% went to non-formal education (e.g. Almajiris).

Table 5: Occupation of Respondents

Occupation	Frequency	(%)
Civil servant	22	14.7
Student	18	12
Business	48	32
Farmer	51	34
Others	11	7.3
Total	**150**	**100**

Source: Fieldwork, 2018

Table 3.6 shows that 32% of the respondents are in business, 34% are in farming, 14.7% are civil servants, 12% are students, and 7.3% are in other businesses that are not defined.

Table 6: Period/duration of stay in the Area

Period/Duration	Frequency	(%)
On visit	10	6.7
1 – 10	51	34
11 – 20	46	30.7
21 – 30	23	15.3
31 and above	20	13.3
Total	**150**	**100**

Source: Fieldwork, 2018

Table 8 shows the duration of the respondents' stay in their various settlements: 34% have been living for between 1 and 10 years, 30.7% between 11 and 20 years, 15.3% between 21 and 30 years, 13.3% between 31 and above years, and finally, 6.7% are on a visit. This shows that the respondents must have a good knowledge of the causes and effects of road transport accidents along Zaria to Soba Road.

Table 7: How will you describe a road accident along Zaria to Soba Road?

Response	Frequency	(%)
High	78	52
Moderate	46	30.7

Low	26	17.3
Total	**150**	**100**

Source: Fieldwork, 2018

Table 3.8 indicates the level of road transport accidents along Zaria to Soba. 52% described accidents along the road as high, 30.7% described them as moderate, and 17.3% described them as low. This shows that the number of road traffic accidents along the road is high.

Table 11 shows that 39% of the respondents described road traffic accidents along Zaria to Soba as high, 27.5% said they were moderate, and 9.5% said they were low.

Table 8: Causes of road traffic accident along this road

Response	Frequency	(%)
Bad road	88	58.7
Careless driving	34	22.7
Illiteracy	3	2
Drunkenness	7	4.6
Lark of regard for road signs	5	3.3
Over speeding	13	8.7
Total	**150**	**100**

Source: Fieldwork, 2018

Table 12 shows that 58.7% of the respondents blamed road traffic accidents on the bad and poor condition of the road. 22.7% said it was a result of careless driving, 6.5% said it was due to overspeeding, drunkenness (3.3%), or lack of regard for road signs, and just 2% said it was due to illiteracy. With this result, we can say that bad roads and drivers' carelessness cause accidents on most occasions along the route.

Table 9: Time of the day that accident occur most

Response	Frequency	(%)
Morning	27	18
Afternoon	70	46.7
Night	53	35.3
Total	**150**	**100**

Table 13 shows that 35% of the accidents mostly occurred at noon (12-4 p.m.), 26.5% said it occurred mostly at night (5-10 p.m.), and 13.5% occurred in the morning.

Table 10: Why this time?

Response	Frequency	Percentage (%)
Rushing to place of work in the morning	42	28
Rushing to come back home	27	18
High congestion of people and motorists in the afternoon (business)	63	42

Dizziness after working for the whole day	18	12
Total	**150**	**100%**

Source: Fieldwork, 2018

Table 10 explains why accidents mostly occur during the time of the day, as shown in Table *4.12* above. 42% see it as a result of high congestion of people and vehicles, especially in the afternoon due to business activities (markets), 28% see it as a result of rushing for work, especially in the morning, 18% relates to people rushing to come back home after closing from their places of work and coming back from the market and lastly, 12% said the accident occurred because people use to get tired and become more fatigue and result into accidents.

Table11: Days of the week that accidents occur most

Response	**Frequency**	**(%)**
Sunday	8	5.3
Monday	15	10
Tuesday	20	13.3
Wednesday	27	18
Thursday	42	28
Friday	13	8.7
Saturday	25	16.7
Total	**150**	**100**

Source: Fieldwork, 2018

Table 11 shows that 28% of the accidents occurred on Thursday, 18% on Wednesday, 16.7% on Saturday, 13.3% on Tuesday, 10% on Monday, 8.7% on Friday, and 5.3% on Sunday. This shows that accidents occurred mostly on Thursdays due to the Tudun-Saibu Market.

Table 12: Why this time of the week?

Response	**Frequency**	**(%)**
T/Saibu Market Day	92	61.3
Soba Market Day	40	26.7
Anchau Market Day	18	12
Total	**150**	**100**

Source: Fieldwork, 2018

Table 16 shows that there are three major markets which used to attract high traffic due to the population that goes there for business and other purposes. 61.3% of the respondents reacted to the T/Saibu market, which operates on Thursdays, as the major factor that causes accidents mostly. 26.7% related to the Soba market, which operates twice a week (i.e. Wednesday and Saturday), and lastly, 12% as a result of the Anchau market, which operates on Tuesday. The three markets are just a short distance from Zaria.

Table 13: What months of the year does an accident occur most?

Response	**Frequency**	**(%)**
January – march	48	32

April - June	27	18
July - September	20	13.3
October - December	55	36.7
Total	**150**	**100**

Source: Fieldwork, 2018

Table 17 shows that the months between October and December, with 36.7%, have the highest cases of accidents because it is the harvest period when farmers take their crops to the market for sale. Similarly, 32% happened between January and March, but the rate declined around April - June, 18%, and July - September, 13.3% because people travel less and most farmers are on their farms.

Table 13: Have you been involved in a road accident along this road?

Response	**Frequency**	**(%)**
Yes	63	42
No	87	58
Total	**150**	**100**

Source: Fieldwork, 2018

Table 18 shows that 58% of the respondents have not been involved in a road accident, but they still complain about the frequent occurrence of accidents, while 42% admitted to having been involved in a road accident along the Zaria to Soba Road.

Table 14: Causes of accident

Response	**Frequency**	**(%)**
Bad road	62	41.3
Careless driving	34	22.7
Over speeding	43	28.7
Drunkenness	11	7.3
Total	**150**	**100**

Source: Fieldwork, 2018

Table 19 shows that the majority of the accidents, 31%, occurred as a result of bad roads, 21.5% as speeding, 17% careless driving and finally, 7.3% as a result of drunkenness and drug abuse by some drivers before driving.

Summary of findings

1. It was discovered that the major causes of accidents are Bad Roads, overspeeding, and Dangerous Driving, especially wrong overtaking.
2. Accidents occur mostly in the afternoon and evening (12-7 pm and 8 pm and above) because by then, almost all commercial/transportation activities are at their peak. Due to the high population in the area, this leads to accidents, and secondly, people rush to come back home, especially in the evening.
3. The research also discovered that accidents occur mostly on Tuesdays, Wednesdays and Thursdays because of the Soba and Tudun-Saibu markets, which are located along the road and not too far from Zaria.

4. The months with the highest accident cases between October and December because at that time, farmers are harvesting their farm produce and taking it to the markets; it can also be associated with the festive period, i.e. Christmas and New Year celebration

Conclusion

The provision of roads in an urban area and those that link them with the rural areas is very important for the efficient and effective movement of people, goods, and services within and outside the urban area. Based on the findings, the majority of the people are village settlers with little or no formal education. Hence, they depend mostly on farming as their major business and means of living, so there is a high dependency ratio on the nearby city, Zari, for sales of their farm produce and buying of some social amenities from the city. Secondly, this road was constructed more than 40 years ago and is the same route that connects Zaria to other places like Jos, Bauchi, Borno and Gombe. This leads to the degradation of the road to its present state. So, the road now is seriously bad, which is the major causal factor of the accident there. There also needs to be more consideration given to the condition of the road and the available measures to reduce accidents by the government and stakeholders. However, given the increasing number of road traffic accidents along the road, calls for concern of stakeholders in the sector. This study was concluded by advocating the need for government and stakeholders to consider the increasing accident cases along the route and repair or reconstruct the road and to evolve a sustainable strategy (by creating awareness among the road users) to curtail carnages on our roads involving transport operations and introduce the use of safety transport systems in the enforcement of traffic rules and regulation. Usman et al (2015).

Recommendations

Based on the findings from the data analysis, the following are recommended to check for frequent road accidents on Zaria—Soba highways.

i.   The government should put more effort into reconstructing the route or refilling the potholes, especially in areas with high accident rates.
ii. The FRSC should carry out public awareness by educating drivers and improving the enforcement of road traffic laws.
iii. Road infrastructure, such as road signs, bridges, street lights, etc., should be adequately maintained and, if possible, improved along the entire route.
iv. A vehicle examination unit is needed for regular inspection of all vehicles.
v.   Road safety education should be organised within a lifetime framework, using aggressive public information campaigns.

REFERENCES

Aderamo, A. J. (2008). Road traffic accident deaths and socio-economic development in Nigeria. *International Review of Business and Social Sciences, 1*(5), 47–50.

Aderamo, A. J. (2012). Spatial pattern of road traffic accident casualties in Nigeria. *Mediterranean Journal of Social Sciences, 3*(2), 15–28.

Adiele, S. C. K. (2011). *An empirical investigation into Nigeria road accident causation factors.* University Press.

Akinyemi, E. O. (2009). Contributing road factors in accidents on rural roads in Nigeria. In Asalor, Onibere, & Ovuworie (Eds.), *Road traffic accidents in developing countries* (Vol. 1). Joja Press.

Andrey, J. (2010). Long-term trends in weather-related crash risks. *Journal of Transport Geography, 18*(2), 247–258.

Anyata, B. U. (2009). *Highway drainage and road maintenance as aspects of highway safety.* University Press.

Asalor, J. O. (2010). *Towards improved road safety in Nigeria.* Technical Report No. Rts/00/82/011, Faculty of Engineering, University of Benin.

Asogwa, S. E. (1978). Road traffic accidents: The doctor's point of view. *African Journal of Medical Science, 7*, 29–35.

Atubi, A. O. (2010). Spatial and temporal perspective on road traffic accident variations in Lagos Mainland, Southwestern Nigeria. *African Research Review, 14*(1), 256–272.

Atubi, A. O. (2012). Epidemiology of injuries from road traffic accidents in Lagos State, Nigeria. *International Journal of Science and Technology, 1*(2), 56–75.

Bastide, S., Moatti, J. P., Pages, J. P., & Fagan, F. (1989). Risk perception and social acceptability of technologies: The French case. *Risk Analysis, 9*, 215–223.

Bala, N. (2014). *Road safety audit and case study of Kano-Kaduna road in Nigeria.* [Unpublished master's thesis]. Department of Civil Engineering, Graduate School of Natural and Applied Science, Atilim University.

Bennett, K. D. (2010). Spatial analysis of motor vehicle accidents in Johnson City, Tennessee. *World Academy of Science, Engineering and Technology,* 126–131.

Daramola, A. Y. (2004). Innovative options for financing transport infrastructure in Nigeria. *Nisereel, the Magazine of the Nigerian Institute of Social and Economic Research,* (485), December.

David, J. B. (2003). *The GIS primer: An introduction to geographic information systems.*

Deepthi, J. K., & Ganeshkumar, B. (2010). Identification of accident hot spots: A GIS-based implementation for Kannur District, Kerala. *International Journal of Geomatics and Geosciences, 1*(1), 51–59.

Federal Road Safety Corps. (2012). *Nigeria road safety strategy (NRSS) 2012-2016.*

Federal Road Safety Corps. (2015, July 24). Overspeeding accounts for 65% of road traffic accident in Plateau State. *Plateau News Online.* Retrieved from https://plateaunewsonline.wordpress.com

Gbadamosi, K. T. (2002). *Traffic regulations and road traffic accidents in Nigeria – A spatial analysis.* [Unpublished doctoral dissertation]. Department of Geography, University of Ibadan.

Gowin, A. C. (2012, February). Valleys of death: Top dangerous federal roads in Nigeria. *Daily Post Nigeria.* Retrieved from www.dailypost.com.ng/

Gururaj, G. (2004). Alcohol and road traffic injuries in South Asia: Challenges for prevention. *JCPSP, 14*(12), 713–718.

Isa, J. U. F., & Falola, J. A. (2011). An evaluation and sequencing of highway for rehabilitation in Northern Nigeria using dynamic programming. *British Journal of Science, 2*(1), 37–45.

James, E. J. (2000). *Development control in Kaduna Metropolis, an example of Tafawa Balewa Way residential extension.*

Jibril, M. S., & Wabundani, J. (2014). Temporal presentation of RTA frequencies along Kaduna-Zaria expressway, Nigeria. *The International Journal of Engineering and Science, 3,* 12–20.

Kaduna State Government. (2012). *The state at a glance.* [Unpublished handbook].

Komba, D. D. (2006). *Risk factors and road traffic accidents in Tanzania: A case study of Kibaha District.* [Master's thesis, Norwegian University of Science and Technology].

Lord, D., Guikema, S. D., & Geedipally, S. R. (2008). Application of the Conway-Maxwell–Poisson generalized linear model for analyzing motor vehicle crashes. *Accident Analysis and Prevention, 40*(3), 1123–1134.

Lupton, D. (1999). *Risk.* Routledge.

Milton, J. C., Shankar, V. N., & Mannering, F. L. (2008). Highway accident severities and the mixed logit model: An exploratory empirical analysis. *Accident Analysis & Prevention, 40*(1), 260–266.

Nizah, S. P. (2008). *A geographic analysis of the growth of road network in Kaduna State from 1976-2006.* [Unpublished undergraduate project]. Department of Geography, Ahmadu Bello University.

Odugbemi, O. O. (2010). *Road transportation and tourism in Nigeria.* Joja Press.

Olajuyigbe, A. E., Ogan, V., Adegboyega, S. A., & Fabiyi, O. (2014). Spatio-temporal analysis of road accidents in Abuja, Federal Capital Territory, Nigeria, using GIS techniques. *Journal of Scientific Research & Reports, 3*(12), 1665–1688.

Paul, D. J. (2015). *Analysis of road traffic accident hotspots along Zaria-Kaduna expressway, Kaduna State, Nigeria.*

Rankavat, S., & Tiwari, G. (2013). Pedestrian accident analysis in Delhi using GIS. *Proceedings of the Eastern Asia Society for Transportation Studies, 9.*

Sagberg, F., & Glad, A. (1999). Traffic safety for the elderly: Literature study, risk analyses, and assessment of safety measures. *Osho Institute of Transport Economics.*

Sarin, S. M. (2000). Road traffic safety in India: Issues and challenges ahead. *Indian Highway.*

Usman, J. G., Adeyemi, M. B., Mu'azu, H., Mohammad, H., & Ibrahim, M. (2015). *An assessment of road traffic accident in Zaria urban area, Kaduna State, Nigeria.*

Xie, Z., & Yan, J. (2008). Kernel density estimation of traffic accidents in a network space. *Journal of Computer, Environment and Urban Systems, 32*, 396–406.