Spatio – Temporal Analysis of Characteristics and Causes of Road Traffic Crashes in Oyo State of Nigeria

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ABSTRACT

BACKGROUND

Millions of people each year will spend long weeks in hospital after severe crashes. The WHO estimated that 1.3million people were killed by road traffic crashes (RTC) and 50 million injured on the worlds road annually, adding that over 80 percent of the figure occurred in developing countries, with Africa having the highest death rate. Also, WHO predicted that if nothing is done by countries to stem the tide, death by RTC would increase by 65% by 2015 to 2020, overtaking malaria and tuberculosis. This paper is aimed at investigating the characteristics, causes and spill over effects of RTC in Oyo state for two periods, namely years 2011 and 2012.

METHODS

The total number of RTC cases and causes recorded in Oyo state where observed for the two periods under study. The total number of persons killed, number injured, sex and age of victims on each RTC incident was obtained. The causes were classified under four headings: dangerous driving, speed limit violation, mechanical fault and human factors. The multiple bar chart was used for comparative purposes. The Moran's Index and a complimenting statistic; the Getis and Ord statistic was used to ascertain spill over effects.

RESULT

Number of RTC varied over the two periods. RTC is characterized by deaths and injuries of adult males. The causes vary from one LGA to another, but similar within contiguous LGAs.

CONCLUSION

The results should enable the orientation of deaths and injury prevention policies targeted on the adult males in the state.

Keywords: *Spatial Hotspots; Road Traffic Crashes; Injuries and Deaths; Nigeria.*

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INTRODUCTION

Millions of people each year will spend long weeks in hospital after severe crashes and many will never be able to live, work or play as they used to do. In some instances, a portion of persons injured end up dying. Road traffic injuries (RTI) are growing health issues disproportionately affecting vulnerable groups of road users, including the poor. More than half the people killed in traffic crashes are young adults aged between 15 and 44years often the bread winners in a family. The World Health Organization (WHO)[1] concludes that RTI cost low income and middle income countries between 1 percent and 2 percent of their gross national product more than the total development aid received by these countries.

Furthermore, the WHO estimated that 1.3million people were killed by road traffic crashes (RTC) and 50 million injured on the worlds road annually, adding that over 80 percent of the figure occurred in developing countries, with Africa having the highest death rate. Also, WHO predicted that if nothing is done by countries to stem the tide, death by RTC would increase by 65% from 2015 to 2020, overtaking malaria and tuberculosis [2].

In 2010 the governments of the world declared 2011–2020 as the Decade of Action for Road Safety. The unanimous support for this Decade of Action from Member States explains the growing awareness of the devastating scale of RTI as a global public health and development problem. RTI are estimated to be the eighth leading cause of death globally. They are the leading cause of death for young people aged 15-29 years, and as a result take a heavy toll on those entering their most productive years. Economically disadvantaged families are hardest hit by both direct medical costs and indirect costs such as lost wages that result from these injuries. Despite the enormous toll exacted by RTI, RTI has for many years been neglected by global health and development agendas. This is regardless of the fact that RTI are largely preventable and that the evidence base for effective interventions is extensive [3].

The occurrence of road accidents inflicts burden on the community which may be considered in two parts. Firstly are the pain, fear and suffering imposed by the occurrence, or the risk of occurrence of road accidents. These are considered of great importance in a society that values human life and human welfare. Second, is the more concrete and ascertainable burdens in the form of the net loss of output of goods and services due to death and injury and the expenditure of resources necessary to make good the effects of accidents.

Reynolds [4] in a study in Britain estimated the burdens of medical expenses, vehicle repairs and costs of administration of RTI. The study attempted to measure how much the community of Great Britain is worse off in terms of measurable costs by the existence of road accidents. The estimates contained only the minimum values that can be placed on the consequence of road accidents, which cannot be a complete guide to the policy to be adopted and the expenditure to be incurred on accident prevention. The effects of road accidents were discussed summarily as damage to property, medical costs, administrative costs, net reduction in output of goods and services, with allowance being made in the case of persons killed and economic effects of a smaller population and a slightly different age/sex occupational structure.

Plasencia and Borrell [5] estimated the incidence of morbidity and mortality due to injuries in the population over the age of 14 years in Barcelona, Spain. Injury distribution according to sex, age, external cause, place of occurrence of the injury and severity was also obtained. Injury morbidity and mortality amongst residents of Barcelona follow sex, age and cause of injury patterns which are, overall, comparable to those observed in other industrialized countries, suggesting that similar etiologic factors might be operating in those areas.

RTI are a major public health problem. Leveque et al [6] chose Years of Potential Life Lost (YPLL) to analyse the trends during the period 1974 to 1994 and the relative impact of the traffic injuries death on total mortality and on total avoidable mortality in Belgium. The paper analysed the geographical trends over a 20 year period at the district level. The geographical analysis showed marked differences between districts. Even though a favourable trend was observed for the traffic injuries deaths in Belgium it is important to highlight the important slowing down of this trend during the most recent years. The study concluded it is also necessary to underline the importance of geographical disparities in the distribution of YPLL rates within the entire population.

Cirera et al [7] described the characteristics of motor vehicle (MV) injury cases admitted to Emergency departments (ED), and assessed factors related to injury severity and hospital admission. The subjects were MV injury patients, aged 16 or more and admitted to four EDs in the city of Barcelona (Spain) from July 1995 to June 1996. Severity was assessed with the Abbreviated Injury Scale and the Injury Severity Score. Univariate and bivariate descriptive statistical analyses were performed, as well as multiple logistic regressions. For the 3791 MV injury cases included in the study period, a larger contribution of cases was noted for males (63.1%), for cases younger than 30 years (55.3%) and for motorcycle or moped occupants (47.1%). After adjusting for age, sex and the presence of multiple injuries, pedestrians, followed by moped and motorcycle occupants were at a higher risk of a more severe injury. Correspondingly, these user groups also showed a higher likelihood of a hospital admission when attended to in an ED. Injury cases attended to in the ED during night hours were also at a higher risk of a hospital admission.

Labinjo et al [8] explored the epidemiology of RTI in Nigeria and provided data on the populations affected and risk factors for RTI. The RTI rates for rural and urban respondents were not significantly different. Increased risk of injury was associated with male gender among those aged 18 to 44 years. Simple extrapolations from the survey suggested that over 4 million people may be injured and as many as 200,000 potentially killed as the result of the menace annually.

In order to enhance prioritization of the burden of RTC, Chandran et al [9] calculated years of life lost and reduction in life expectancy using population and crash data from Brazil's ministries of health and transport. The potential for reduction in crash mortality was calculated for hypothetical scenarios reducing death rates to those of the best performing region and age category. For males, at birth, RTC reduced the life expectancy by 0.8 years and 0.2 years for the females. The study concluded many years of life lost for men and women could be averted if all rates matched those of the lowest risk region and age category.

Ezel et al [10] piloted a systematic mortuary-based data collection in Ibadan to determine the nature and circumstances of fatal RTI and assess data quality against existing data sources. Using a draft data collection system developed jointly by WHO and Monash University, the detailed information was prospectively collected on RTI University College Hospital mortuary admissions in Ibadan from September 2010 to February 2011. Demographics, road user type, counterpart vehicle, intent, manner and medical cause of death were recorded. Findings showed mortuary admissions included 80 fatal RTI cases: 81.3% males. By road user category, 28 (35.0%) were pedestrians; 28 (35.0%) motorised 2 wheeler users; 18.8% car occupants; and 11.3% bus occupants. In 70% of cases, medical cause of death was head injury, including 25 of 28 motorised 2 wheeler users (89.3%). Estimates from this study indicate apparent increased mortuary capture of fatal RTI compared with police data. The paper demonstrates the feasibility of collecting detailed, timely RTI fatality data through mortuary based surveillance in Ibadan. While not all RTI deaths are reported to any authority in Ibadan, this large case series compliments existing data sources and suggests that pedestrians and motorised 2-wheeler users die most often in RTC. Frequent head injuries among motorised 2-wheeler users strongly support the need for helmet wearing.

In February 1988, the Federal Government created the Federal Road Safety Commission through Decree No. 45 referred to in the statute books as the FRSC Act cap 141 Laws of the Federation of Nigeria (LFN). Prior to this time, the Nigerian Police Force established in 1930 was saddled with the responsibility of keeping road traffic accident records. The Federal Government's intervention on road traffic accidents by the establishment of FRSC in 1988 led to concrete, deliberate and sustained policy action to address road safety issues. Activities of FRSC such as overhauling the national drivers' license scheme, review and re-engineering of the vehicle license data base, highway patrol, ambulance services, public education programme on drivers' road traffic habits and keeping of offenders registry are factors that have helped to check the frequency of road mishaps and indirectly led to a decline in the trend of road traffic crashes from 1988[11].

In Nigeria, RTC death rate is 162 deaths per 100,000 populations as stated by Ogbodo and Nduoma[12]. This is against the expected world average of 22 deaths per 100,000 populations Sukhai et al [13]. Thus, the Nigerian RTC death rate is disproportionately high in comparison to the world average by over 636%. This paper is aimed at investigating the characteristics, causes and spill over effects of RTC in Oyo state, Nigeria for two periods, namely years 2011 and 2012. The state is the major link between the northern parts of the country and the busiest city (Lagos). The focus is on the frequency of deaths and injuries that results from this menace and thus will enable the orientation of deaths and injury prevention policies in the state.

The research question is whether there is spill over effects (spatial dependence) of causes of RTC across the study area. That is, for instance, does the cause of RTC at a particular location influence the cause at a neighbouring locality? The underlying assumption is that RTC are caused by certain actions of man, which may not necessarily be aimed at causing accidents. These human behaviours invariably, make RTC unavoidable.

METHODS

Data and Data Source

Data on all recorded RTC cases and traffic volume for 2011 and 2012 was obtained from the Federal Road Safety Commission RS11.3 Oyo sector command with headquarters at Eleyele, Ibadan in Oyo state. The FRSC Oyo sector command comprise of ten unit commands, each unit command has designated service routes within the Local Government Areas (LGAs). The unit commands and the LGA they oversee are as follows: RS11.30 Eleyele unit command: Ibadan North West and Ibadan South West, RS11.31 Ogbomoso unit command: Ogbomoso South, Ogbomoso North, Ogo Oluwa and Surulere, RS11.32 Oluyole unit command: Ibadan South East, Oluyole, Ona Ara, RS 11.33 Iddo unit command: Ibarapa North, Ibarapa Central, Ibarapa, East and Ido, RS11. 34 Mokola unit command: Ibadan North and Ibadan North East, RS 11.35 Egbeda unit command: Egbeda and Lagelu, RS 11.36 Saki unit command: Saki West, Saki East, Orelope, Atisbo, Iwajowa, Kajola, Itesiwaju, RS11.37 Kisi unit command: Irepo, Olorunsogo and Orire, RS11.38 Atiba unit command: Atiba, Afijio, Oyo East, Oyo West, Iseyin and RS 11.39 Moniya unit command oversees only Akinyele LGA.

The unit command, road/route, location and time of RTC were obtained. The type of vehicles that were involved in the crashes was reported as either government diplomat, commercial or private vehicles. The vehicles' registration numbers, the number of passengers, cause of RTC and total casualties namely; the number of adults injured, number of children injured and the gender of injured persons. Also, the number of adults killed, number of children killed and the gender of persons killed were included in the RTC data. The possible cause of each incidence of accidents is recorded along other information.

The possible causes of accident reported were grouped into four categories for the purpose of this study as follows. Dangerous Driving (DVD): dangerous driving, wrongful overtaking and dangerous overtaking; Speed Limit Violation (SPV): speed limit violation and loss of control; Mechanical Fault (MF): brake failure and tyre burst and Human Factors (HF): driving under alcohol influence, overloading, obstruction and bad road.

Analysis

Descriptive statistics and geographic information system approach was adopted. Multiple bar charts were used for description and comparative purposes, while the Moran's Index and a complimenting statistic (Getis and Ord) were used for hotspot analysis and spatial dependence (spill over effects) assessment.

Moran's I Statistic

Is a global measure for hotspots and spatial dependence developed by Moran [14] in 1948. The index measures spatial dependence based on feature locations and attribute values. The measure evaluates whether the pattern is clustered, dispersed or random. The null hypothesis states that the feature values are randomly distributed across the study area. When the z score or p value indicates statistical significance, a positive Moran's I index value indicates tendency towards clustering while a negative Moran's I index value indicates tendency toward dispersion.

The Moran's I statistic is structured as a Pearson product moment correlation coefficient, plus *W*, the contiguity weights matrix. *Y* is a covariance matrix, that is, the relation between the spatial units is calculated as $(y_i - \bar{y})(y_j - \bar{y})$. The obtained measure is scaled by

$$\frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}}\left[\sum_{i=1}^{n}(y_i - \bar{y})^2\right]$$

By convention, $i \neq j$. As a result,

$$I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum_{i=1}^{n}(y_i - \bar{y})^2} \quad i \neq j$$

,where y_i = the value of variable y on segment i, y = the mean of variable y, n = the number of segments, w_u = a weight indicating if segment i is connected to segment j (e.g. 1) or if it is not (e.g.0).

$G_i(d)$ Statistic

This statistic developed by Getis and Ord [15] in 1992 identifies hotspots and measures the degree of association (spatial dependence) that results from the concentration of weighted points (or area represented by a weighted point) and all other weighted points included within a radius of distance $\Gamma_i = \sum_j W_{ij} Y_{ij}$, $i \neq j$

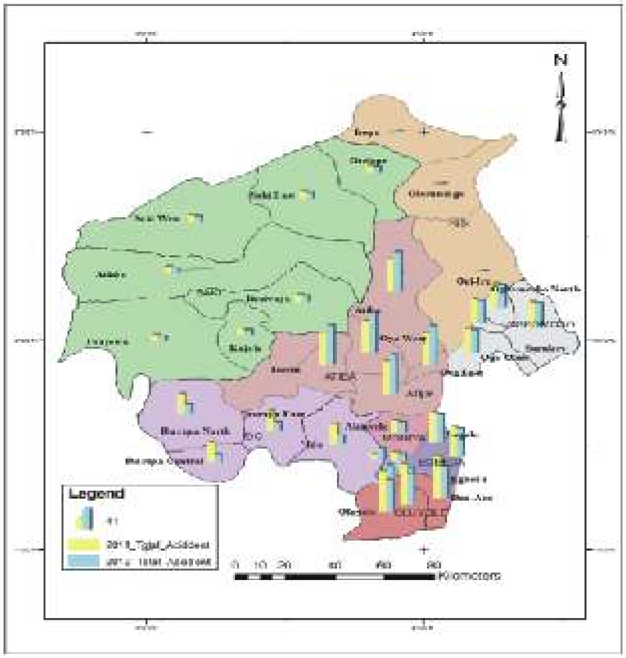
We assume an area subdivided into n regions, $i = 1,2,...,n,$ where each region is identified with a point whose Cartesian coordinates are known. Each i has associated with it a value y (a weight) taken from variable Y. The variable has a natural origin and is positive.

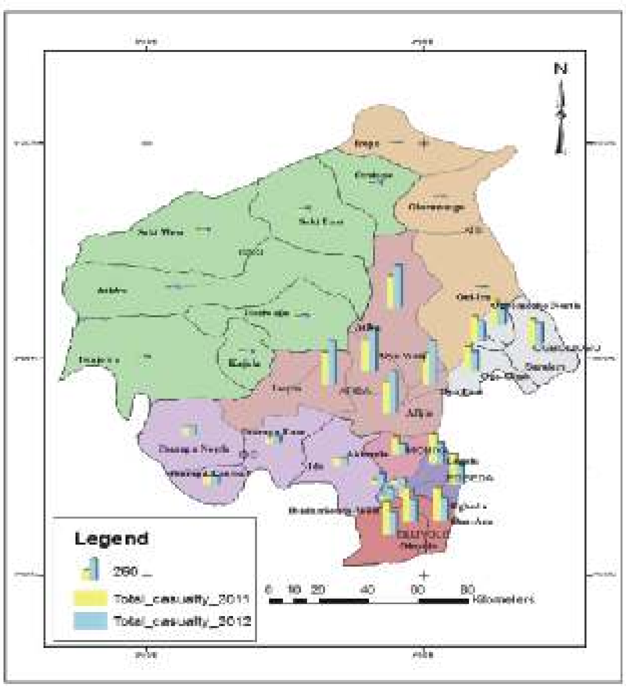
The statistic is, $G_i(d) = \frac{\sum_{j=1}^{n} w_{ij}(d) y_j}{\sum_{j=1}^{n} y_j}$,j not equal to i , where (w_{ij}) is a symmetric one/zero spatial weight matrix with ones for all links defined as being within distance d of a given i; all other links are zero including the link of point i to itself. The numerator is the sum of all y_1 within d of i but not including y_1. The denominator is the sum of all y_1 not including y_1.

RESULTS

Characteristics

Figure 1 shows number of RTC cases in 2011(yellow) and 2012 (blue). Figure 2 shows the total casualties in 2011(yellow) and 2012 (blue).





Next, we consider the categories of persons injured in RTC. Figures 3 shows the number of males (blue) and females (yellow) injured in 2011. Figures 4 shows the number of males (blue) and females (yellow) injured in 2012.

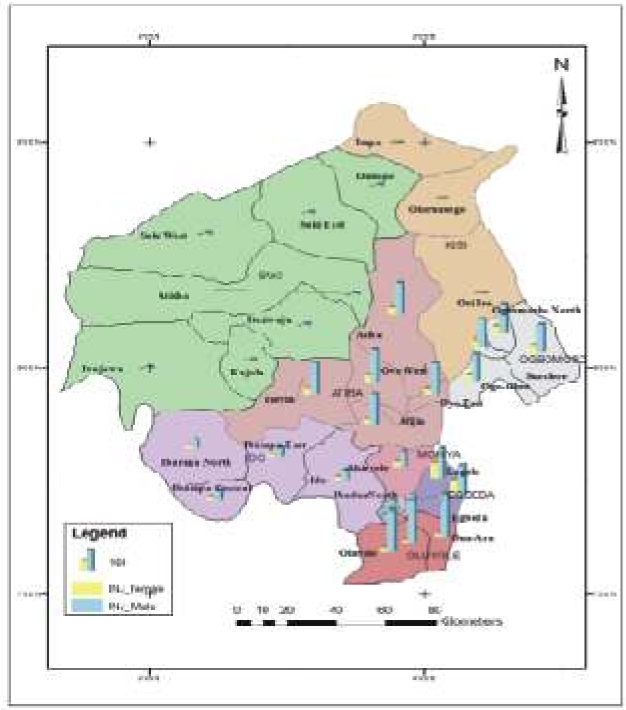


Figure 3: *Geovisual presentation of Males/Females Injured in Road Traffic Accidents 2011*

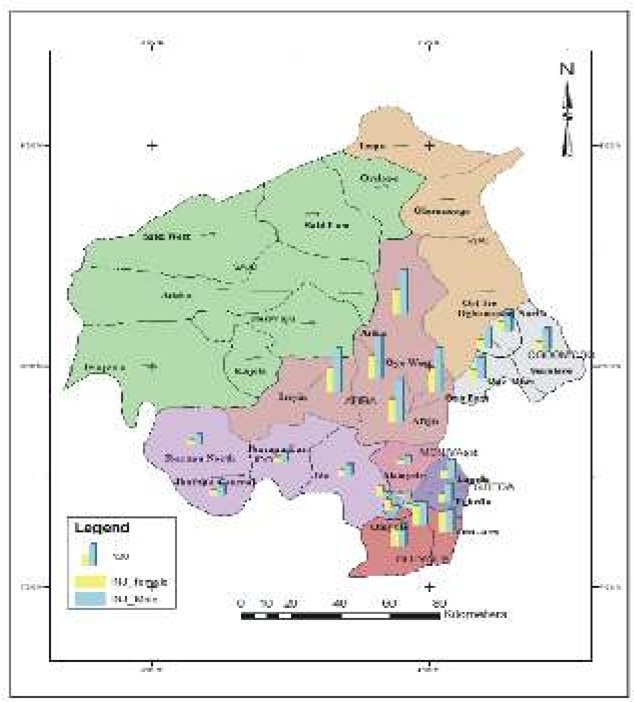


Figure 4: *Geovisual presentation of Males/Females Injured in Road Traffic Accidents 2012*

Figure 5 shows the number of adults (blue) and children (yellow) that sustained injuries as a result of RTC in 2011. Figure 6 shows the number of adults (blue) and children (yellow) that sustained injuries as a result of RTC in 2012.

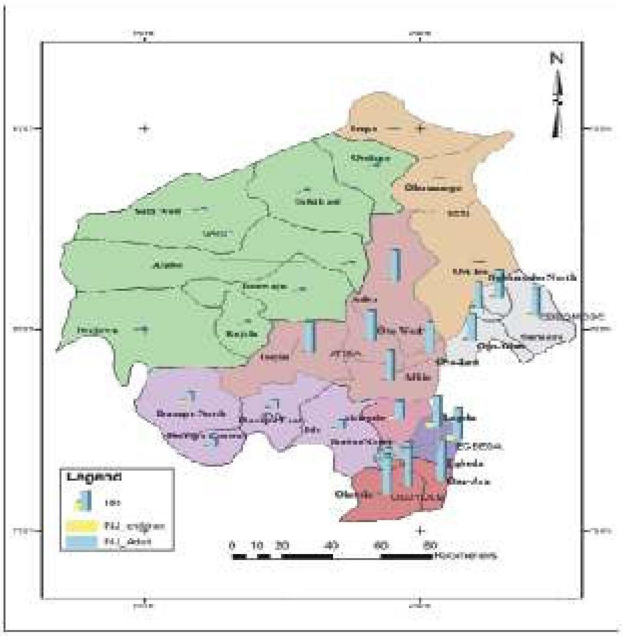


Figure 5: *Geovisual presentation of Children/Adults Injured in Road Traffic Accidents 2012*

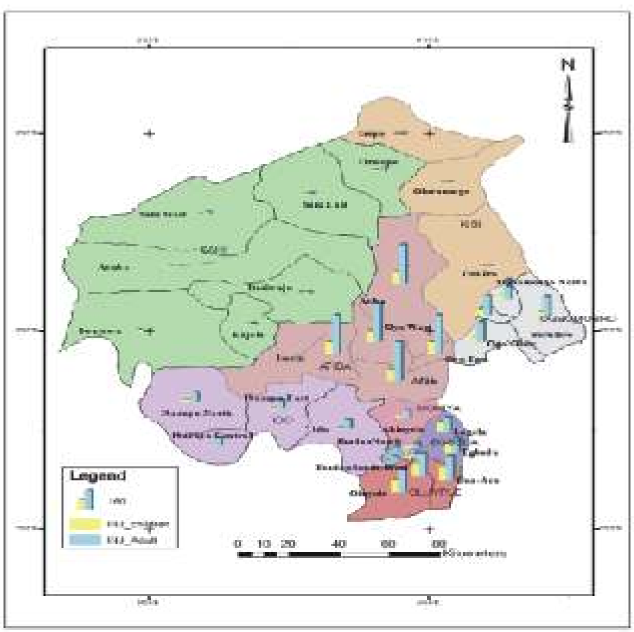


Figure 6: *Geovisual presentation of Children/Adults Injured in Road Traffic Accidents 2011*

In the following section, we consider the categories of persons killed in RTC.

Figure 7 shows the number of males (blue) and females (yellow) killed in 2011. Figure 8 shows the number of males (blue) and females (yellow) killed in 2012.

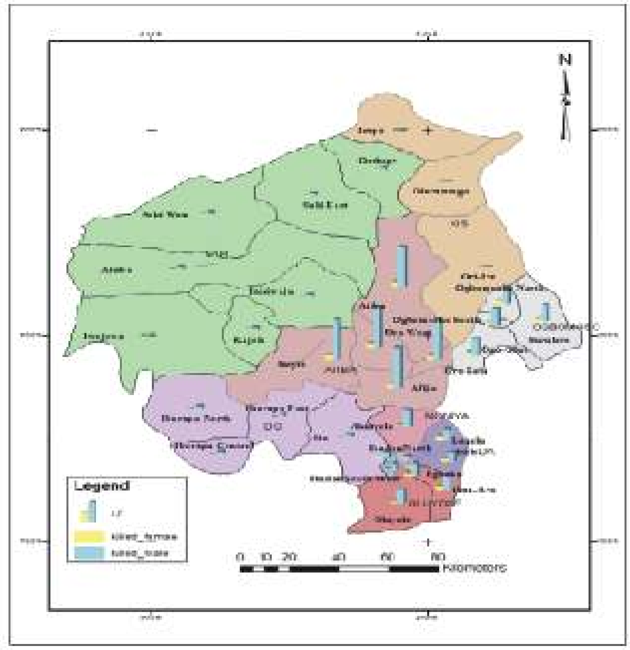


Figure 7: *Geovisual presentation of Males/Females killed in Road Traffic Accidents 2011*

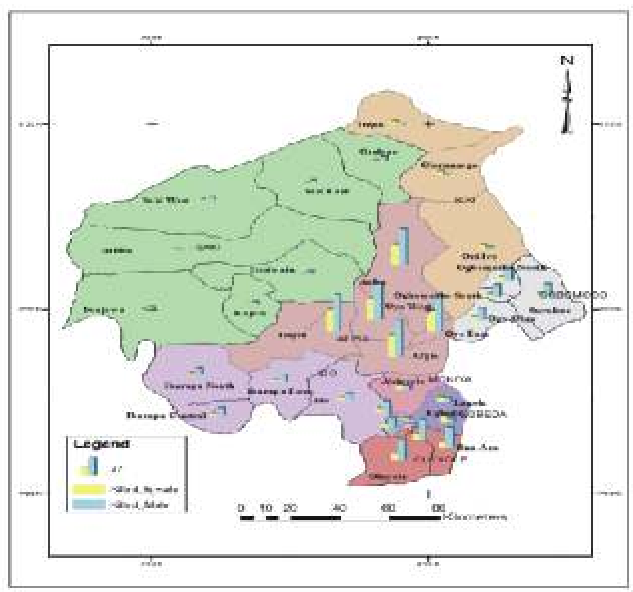


Figure 8: *Geovisual presentation of Males/Females killed in Road Traffic Accidents 2012*

Figure 9 shows the number of children (yellow) and adults (blue) killed in 2011. Figure 10 shows the number of children (yellow) and adults (blue) killed in 2012.

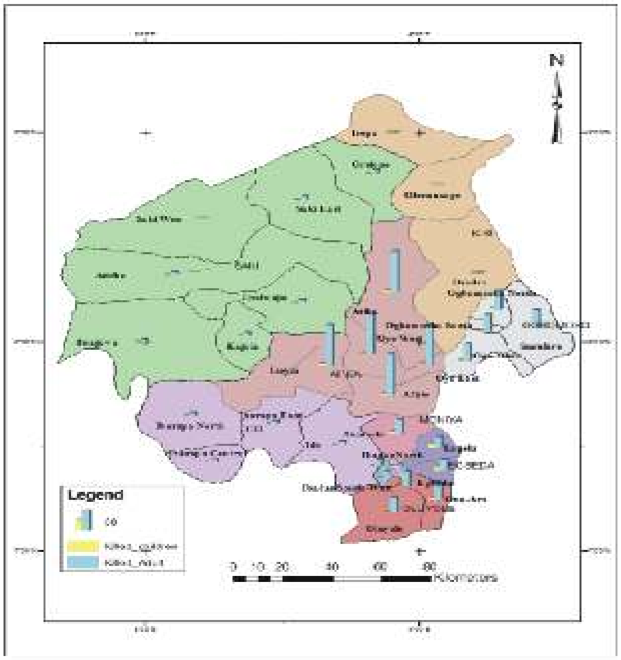


Figure 9: *Geovisual presentation of Children/Adults killed in Road Traffic Accidents 2011*

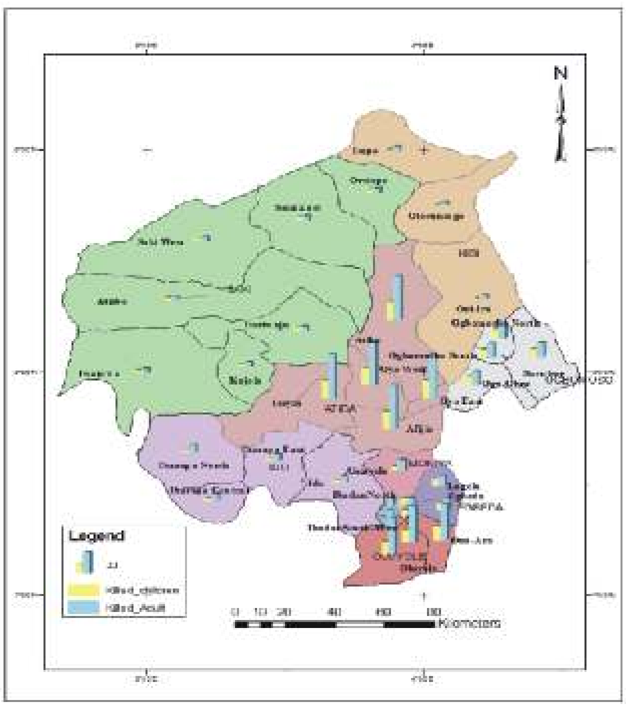


Figure 10: *Geovisual presentation of Children/Adults killedin Road Traffic Accidents 2012*

Causes

The spatial dependence values associated with causes of RTC are given in the next section.

Dangerous Driving

Spill over effects (Moran)

The null hypothesis states that the spatial pattern is random across the study area.

In 2011, the Moran's I Index calculated was 0.29, while the Z score was 3.51 standard deviations, with a P value of 0.01. For 2012, the Moran's I Index calculated was 0.36, while the Z score was 4.37 standard deviations, with a P value of 0.01. This indicates less than 1% likelihood that this clustered pattern could be the result of random chance. (see also, Table 1).

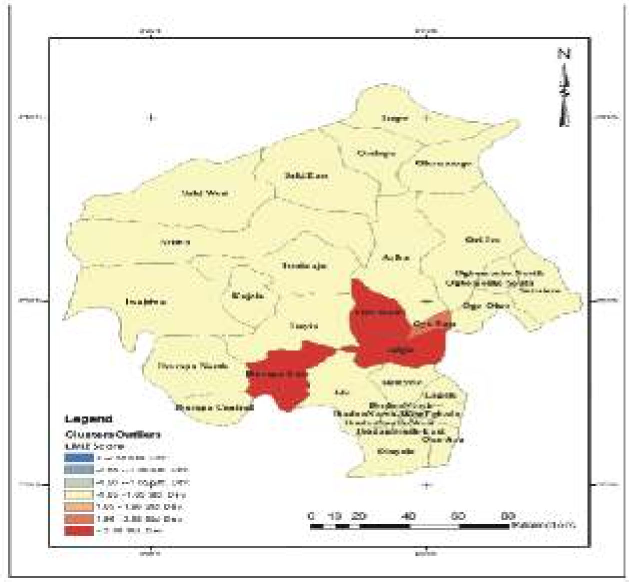


Figure 11: *Geovisual presentation of hotspots for dangerous Driving in 2011 (Moran's)*

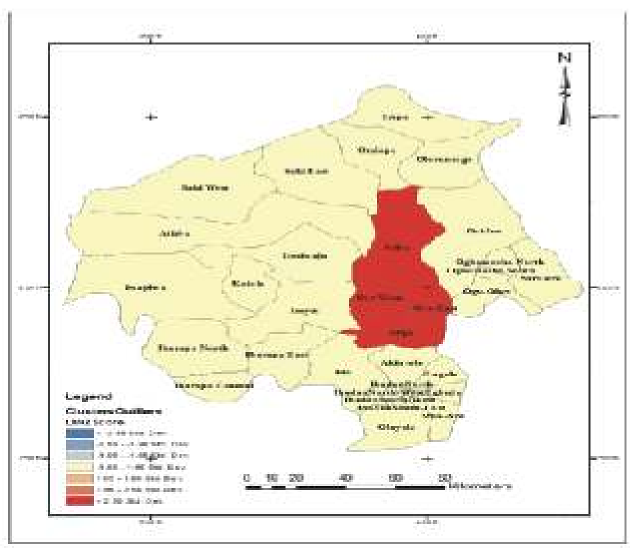


Figure 12: *Geovisual presentation of hotspots for dangerous Driving in 2012 (Moran's)*

Hotspots (Moran)

The hotspots as a result of dangerous driving in 2011 (Figure 11) were on major roads within Oyo West, Oyo East, Afijio and Ibarapa East LGAs. While, the hotspots as a result of dangerous driving in 2012 (Figure 12) were on major roads within Atiba, Oyo East, Oyo West and Afijio LGAs.

Table 1: *Moran's Spatial Dependence for Dangerous Driving among Local Government Areas (LGA): Number of Dangerous Driving in Oyo State, 2011-2012*

YEAR, 2011					YEAR, 2012				
LGA	LMiIndex	LMiZScore	LMi Pvalue	Concentration	LGA	LMiIndex	LMiZScore	LMi Pvalue	Concentration
Oyo West	13.587	7.342	0.000	HH	Oyo West	20.031	11.085	0.000	HH
Ibarapa East	4.876	2.678	0.007	HH	Oyo East	10.616	5.385	0.000	HH
Afijio	5.693	2.663	0.008	HH	Afijio	7.6 30	3.627	0.0003	HH
Oyo East	4.808	2.419	0.016	HH	Atiba	3.412	2.621	0.009	HH

Key : HH =High High

Result reveals high high values of concentration of accident clustering within Oyo West, Ibarapa East, Afijio and Oyo East LGAs in 2011, while, Oyo West, Oyo East, Afijio and Atiba LGAs had the highest concentration in 2012.

Spill over effects (Getis and Ord)

The null hypothesis states that the spatial pattern is random across the study area. The results from the G statistic for testing spatial dependence are given as follow for 2011: G Index of 0.21, with a Z score of 1.12 standard deviations. This indicates that while there is some clustering, the pattern may be due to random chance. While, for 2012, the G index was 0.27 with a Z score of 1.82 standard deviations, indicative of a less than 5-10% likelihood that the clustering of high values could be the result of random chance. (see also Table 2)

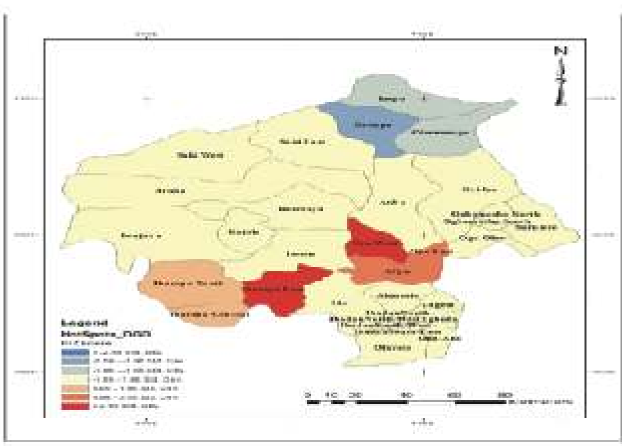


Figure 13: *Geovisual presentation of hotspots for dangerous Driving in 2011 (Getis and Ord)*

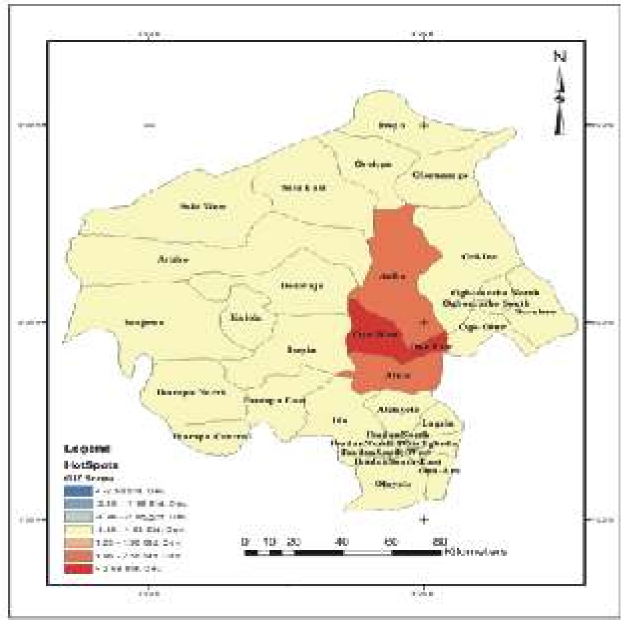


Figure 14: *Geovisual presentation of hotspots for dangerous Driving in 2012 (Getis and Ord)*

Hotspots (Getis and Ord)

The hotspots for RTC as a result of dangerous driving in 2011 (Figure 13) were on major roads within Oyo West and Ibarapa East LGAs. While, the hotspots prone to RTC as a result of dangerous driving in 2012 (Figure 14) were on major roads within Oyo west and Oyo East LGAs.

Table 2: *Getis and Ord Spatial Dependence for Dangerous Driving among Local Government Areas (LGAs): Number of Dangerous Driving in Oyo State, 2011-2012*

(HIGHEST POSITIVE VALUES)

YEAR 2011			YEAR 2012		
LGA	G_i Z Score	G_i P value	LGA	G_i Z Score	G_i P value
Oyo West	4.474	0.000008	Oyo West	5.432	0.0000
Ibarapa East	2.845	0.004	Oyo East	3.151	0.0016
Afijio	2.100	0.036	Afijio	2.405	0.0161
Oyo East	2.009	0.045	Atiba	2.278	0.0230
Ibarapa North	1.824	0.068	None	None	None
Ibarapa Central	1.824	0.068	None	None	None

The hotspots in 2011 include Oyo West, Ibarapa East, Afijio and Oyo East LGAs. In the year 2012 the hotspots include Oyo West, Oyo East, Afijio and Atiba LGAs.

Speed Limit Violation

Spill over effects (Moran)

The null hypothesis states that the spatial pattern is random across the study area.

In 2011, the Moran's I Index calculated equal 0.14. The Z score equal 1.95 standard deviations, while the P value equal 0.10. There is less than 5 to 10% likelihood that this clustered pattern could be a result of random chance. For 2012, the Moran's I Index calculated equal 0.17. The Z score equal 2.38, while the P value equal 0.05. There is less than 5% likelihood that this clustered pattern is the result of random chance. (see also, Table 3).

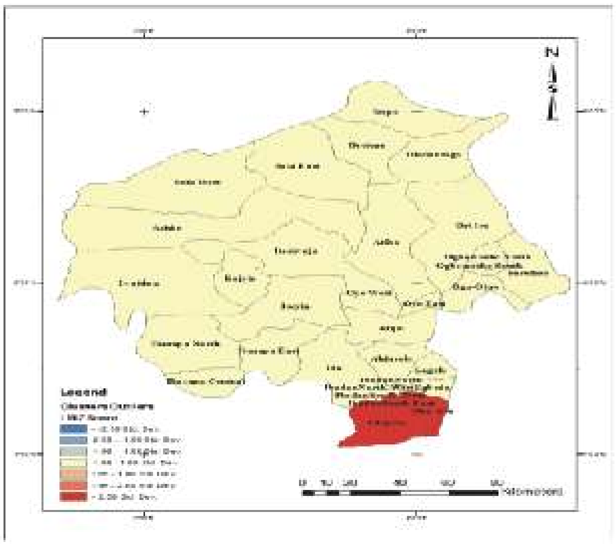


Figure 15: *Geovisual presentation of hotspots for Speed Limit Violation in 2011 (Moran's)*

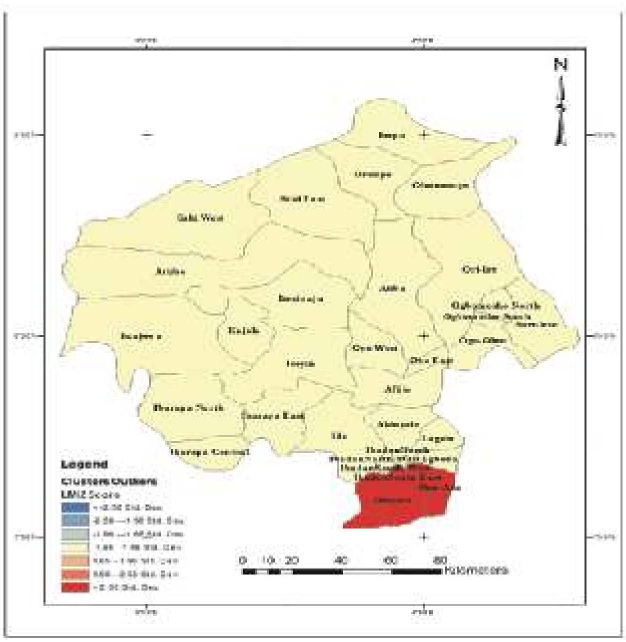


Figure 16: *Geovisual presentation of hotspots for Speed Limit Violation in 2012 (Moran's)*

Hotspots (Moran)

The hotspots as a result of speed limit violation in 2011 (Figure 15) were on major roads within Oluyole, Ona Ara and Ibadan South East LGAs. While, the hotspots as a result of speed limit violation in 2012 (Figure 16) were on major roads within Oluyole, Ona Ara and Ibadan South East LGAs.

Table 3: *Moran's Spatial Dependence for Speed Limit Violation among Local Government Areas (LGA): Number of Speed Limit Violation in Oyo State, 2011-2012*

YEAR, 2011					YEAR, 2012				
LGA	LMiIndex	LMiZScore	LMi Pvalue	Concentration	LGA	LMiIndex	LMiZScore	LMi Pvalue	Concentration
Oluyole	11.250	5.156	0.000	HH	Oluyole	11.725	5.369	0.000	HH
Ona Ara	9.891	4.163	0.000	HH	Ona Ara	11.142	4.675	0.000	HH
IBS	8.013	3.287	0.001	HH	IBS E	9.518	3.882	0.0001	HH

Key : HH =High High; IBSE= Ibadan South East

Result reveals high high values of concentration of RTC clustering within Oluyole,Ona Ara and Ibadan South East LGAs for 2011 and 2012.

Spill over effects (Getis and Ord)

The null hypothesis states that the spatial pattern is random across the study area.

The results from the G statistic for testing spatial dependence are given as follow: In 2011, the G Index was 0.29 with a Z score of 2.55. There was a less than 5 % likelihood that the clustering of high values is the result of random chance. While, for 2012, the G was equal 0.31 while the Z score equalled 3.01 standard deviations. There was a less than 1% likelihood that the clustering of high values could be the result of random chance. (see also Table 4)

Figure 17: *Geovisual presentation of hotspots for Speed Limit Violation in 2011 (Getis and Ord)*

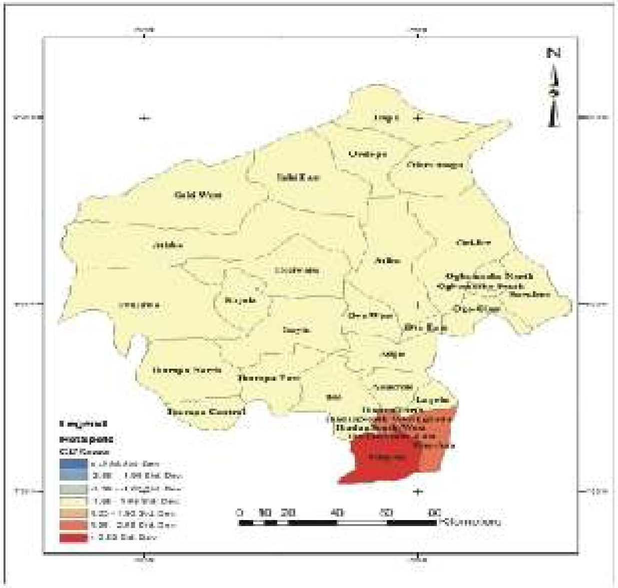


Figure 18: *Geovisual presentation of hotspots for Speed Limit Violation in 2012 (Getis and Ord)*

Hotspots (Getis and Ord)

The hotspots for RTC as a result of speed limit violation in 2011 (Figure 17) were on major roads within Oluyole LGA. The concentration is less significant in Ona Ara, Ibadan North, Ibadan North East, Ibadan North West, Ibadan South East, and Ibadan South West LGAs. In 2012 the hotpots are the same with the later (see Figure 18).

Table 4: *Getis and Ord Spatial Dependence for Speed Limit Violation among Local Government Areas (LGAs): Number of Speed Limit Violation in Oyo State, 2011-2012*

(HIGHEST POSITIVE VALUES)

YEAR, 2011 LGA	G_i Z Score	G_i P value	YEAR, 2012 LGA	G_i Z Score	G_i P value
Oluyole	2.746	0.006	Oluyole	2.831	0.005
Ona Ara	2.395	0.017	Ona Ara	2.562	0.010
Egbeda	2.395	0.01 7	Egbeda	2.562	0.010
Ibadan North	2.212	0.027	Ibadan North	2.436	0.014
Ibadan North East	2.091	0.037	Ibadan North East	2.287	0.022
Ibadan North West	2.091	0.037	Ibadan North West	2.287	0.022
Ibadan South West	2.091	0.037	Ibadan South West	2.287	0.022
Ibadan South East	2.091	0.037	Ibadan South East	2.287	0.022

The hotspots include Oluyole, Ona Ara and Egbeda LGAs in 2011 and 2012.

Mechanical Fault

Spill over effects (Moran)

The null hypothesis states that the spatial pattern is random across the study area.

In 2011, the Moran's I Index calculated was 0.28, with a Z score of 3.52, and P value of 0.01. This indicates less than 1% likelihood that this clustered pattern could be the result of random chance. For 2012, the Moran's I Index calculated was 0.47, while the Z score was 5.54, with a P value of 0.01 and a less than 1% likelihood that this clustered pattern could be the result of random chance (see also, Table 5).

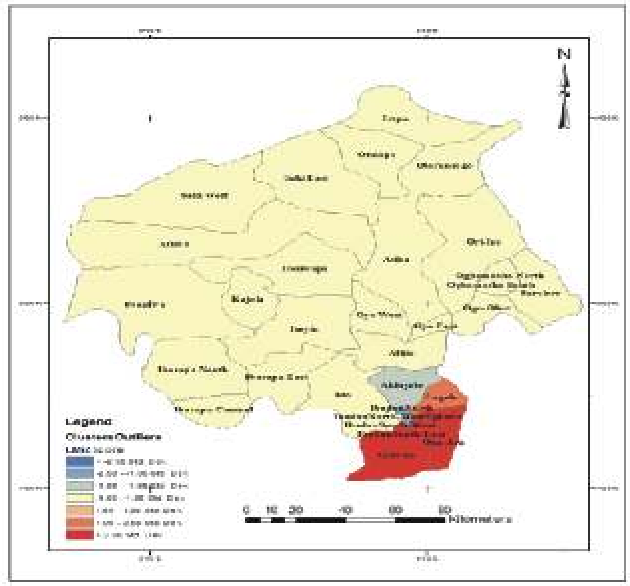
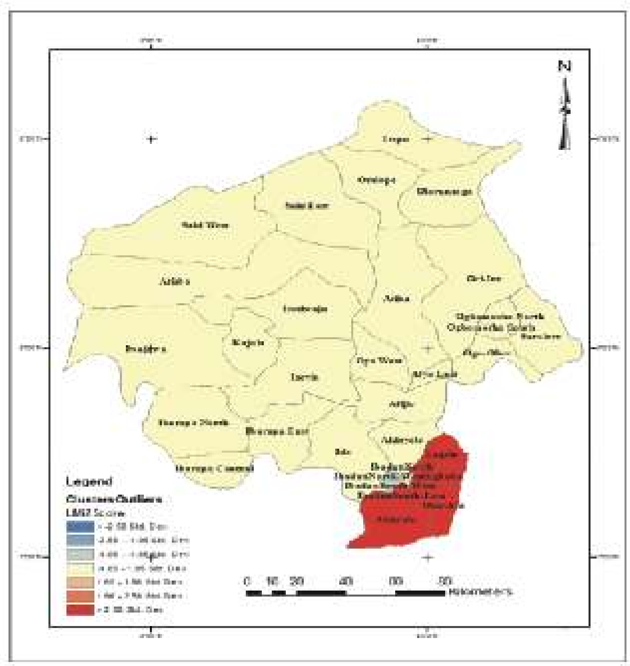


Figure 19: *Geovisual presentation of hotspots for Mechanical Fault in 2011 (Moran's)*



Mechanical Fault in 2012 (Moran's)

Hotspots (Moran)

The hotspots as a result of mechanical fault in 2011 were on major roads within Oluyole, Ona Ara, Lagelu, Ibadan South East and Egbeda LGAs (Figure 19). In addition to these LGAs, in 2012, Lagelu LGA became more concentrated with accidents resulting from mechanical fault (see Figure 20).

Table 5: *Moran's Spatial Dependence for Mechanical Fault among Local Government Areas (LGA): Number of Mechanical Fault in Oyo State, 2011-2012*

YEAR, 2011					YEAR, 2012				
LGA	LMiIndex	LMiZScore	LMi Pvalue	Concentration	LGA	LMiIndex	LMiZScore	LMi Pvalue	Concentration
Oluyole	14.825	6.071	0.000	HH	Egbeda	14.728	5.908	0.000	HH
IBSE	13.884	5.648	0.000	HH	Ona Ara	14.728	5.908	0.000	HH
Ona Ara	12.621	5.514	0.000	HH	IBSE	13.702	5.342	0.000	HH
Egbeda	11.496	4.733	0.000	HH	Oluyole	11.455	5.010	0.000	HH
Lagelu	6.119	2.498	0.013	HH	Lagelu	8.378	3.313	0.001	HH

Key : HH =High High; IBSE= Ibadan South East

Result reveals high high values of concentration of RTC clustering due to mechanical fault within Oluyole, Ibadan South East, Ona Ara, Egbeda and Lagelu LGAs for 2011 and 2012.

Spill over effects (Getis and Ord)

The null hypothesis states that the spatial pattern is random across the study area.

The results from the G statistic for testing spatial dependence are given as follow: for 2011, the G Index was 0.34, while the Z score was 3.91 standard deviations with less than 1 % likelihood that the clustering of high values could be the result of random chance. While, for 2012, the G index was 0.5 while the Z score equalled 5.56 standard deviations with less than 1% likelihood that the clustering of high values could be the result of random chance (see also Table 6).

Hotspots (Getis and Ord)

The hotspots for RTC as a result of mechanical fault in 2011 (Figure 21) were on major roads within Egbeda, Ona Ara, Oluyole, Ibadan South East, Ibadan South West, Ibadan North East, Ibadan North West and Ibadan North LGAs. The hotspots in 2012 were the same LGAs (see Figure 22).

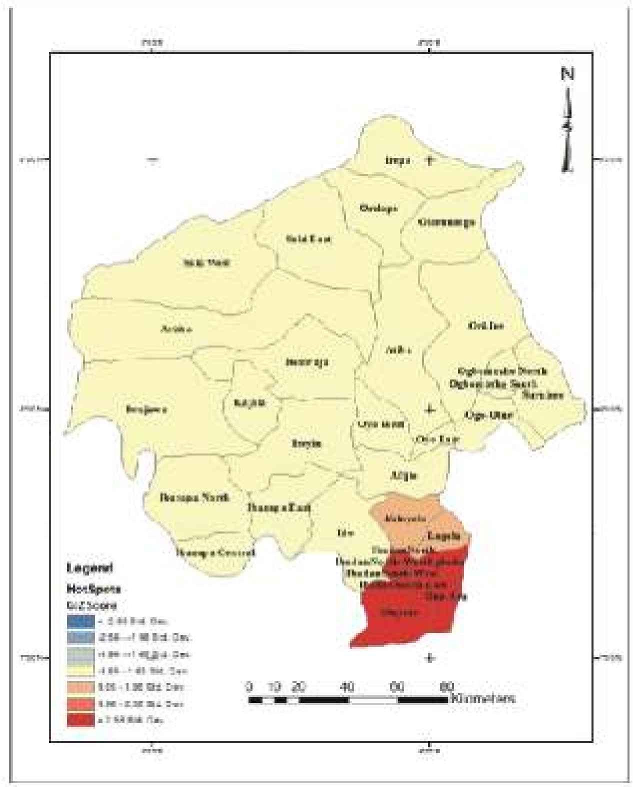


Figure 21: *Geovisual presentation of hotspots for Mechanical Fault in 2011 (Getis and Ord)*

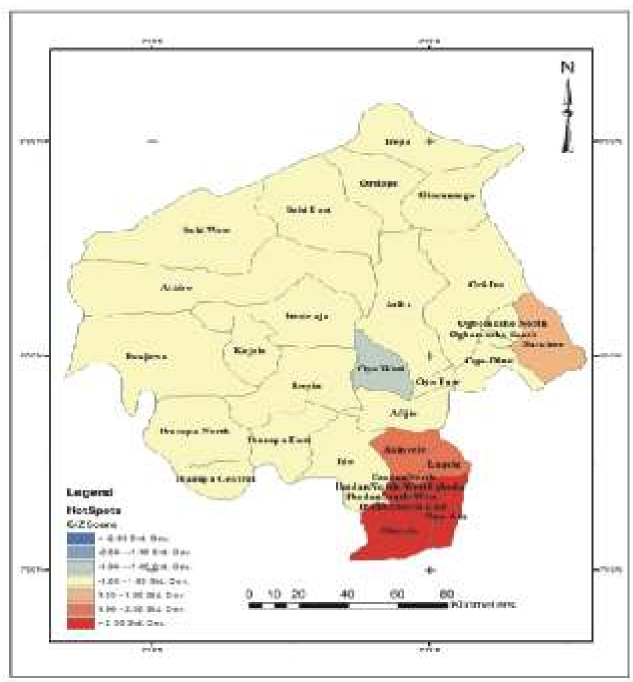


Figure 22: *Geovisual presentation of hotspots for Mechanical Fault in 2012 (Getis and Ord)*

Table 6: *Getis and Ord Spatial Dependence for Mechanical Fault among Local Government Areas (LGAs): Number of Road Traffic Accidents Resulting from Mechanical Faults in Oyo State, 2011-2012*

(HIGHEST POSITIVE VALUES)

YEAR, 2011			YEAR, 2012		
LGA	G_i Z Score	G_i P value	LGA	G_i Z Score	G_i P value
Egbeda	3.176	0.002	Egbeda	3.568	0.000
Ona Ara	3.176	0 .002	Ona Ara	3.568	0.000
Oluyole	3.053	0.002	Ibadan North East	3.287	0.001
Ibadan South East	2.960	0.003	Ibadan North West	3.287	0.001
Ibadan South West	2.960	0.003	Ibadan South East	3.287	0.001
Ibadan North East	2.960	0.003	Ibadan South West	3.287	0.001
Ibadan North West	2.960	0.003	Oluyole	3.155	0.002
Ibadan North	2.824	0.005	Ibadan North	2.964	0.003

For the two periods under consideration the concentration of number of RTC attributable to mechanical fault is high in Egbeda, Ona Ara, Oluyole, Ibadan South East, Ibadan South West, Ibadan North East, Ibadan North West, and Ibadan North LGAs.

Spill over effects (Moran)

Human Factor

The null hypothesis states that the spatial pattern is random across the study area.

In 2011, the Moran's I Index calculated equalled 0.18. The Z score equalled 2.28 standard deviations, while the P value was 0.05, with less than 5% likelihood that this clustered pattern could be the result of random chance.

For 2012, the Moran's I Index calculated was 0.7, with a Z score of 8.02 standard deviations, and a P value of 0.01 indicating a less than 1% likelihood that this clustered pattern could be the result of random chance (see also, Table 7).

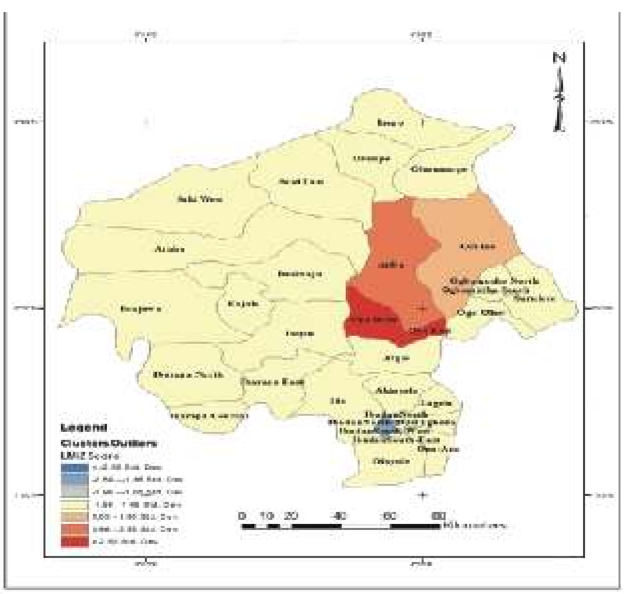


Figure 23: *Geovisual presentation of hotspots for Human Factor in 2011 (Moran's)*

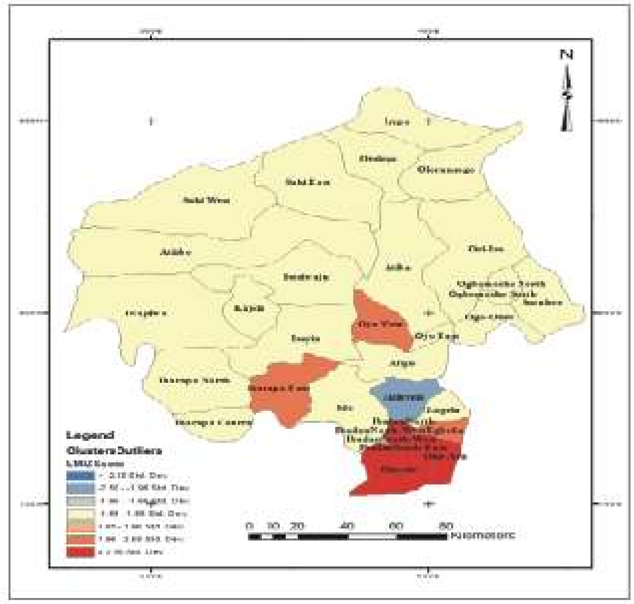


Figure 24: *Geovisual presentation of hotspots for Human Factor in 2012 (Moran's)*

Hotspots (Moran)

The hotspots as a result of human factors in 2011 were on major roads within Oyo West and Oyo East LGAs (Figure 23). In 2012, the concentration became higher in Oluyole, Ona Ara, Ibadan North, Ibadan North East, Ibadan North West, Ibadan South East, and Ibadan South West LGAs (Figure 24).

Table 7: *Moran's Spatial Dependence for Human Factors among Local Government Areas: Number of Human Factors in Oyo State, 2011-2012*

YEAR, 2011					YEAR, 2012				
LGA	LMiIndex	LMiZScore	LMi Pvalue	Concentration	LGA	LMiIndex	LMiZScore	LMi Pvalue	Concentration
Oyo West	5.721	3.092	0.002	LL	Oluyole	18.848	8.138	0.000	HH
Oyo East	5.552	2.749	0.006	LL	Ona Ara	17.961	7.145	0.000	HH
Atiba	2.861	2.113	0.035	LL	Ibadan South East	16.054	6.212	0.000	HH
None	None	None	None	None	Ibadan South West	11.023	4.302	0.000	HH
None	None	None	None	None	Ibadan North East	11.023	4.302	0.000	HH
None	None	None	None	None	Ibadan North West	11.023	4.302	0.000	HH
None	None	None	None	None	Ibadan North	9.823	3.761	0.000	HH
None	None	None	None	None	Egbeda	5.398	2.225	0.026	HH

Key : HH =High High; LL= Low Low

Result reveals high high values of concentration of accident clustering due to human factors within Oluyole, Ona Ara, Ibadan South East, Ibadan South West, Ibadan North East, Ibadan North West, Ibadan North and Egbeda LGAs in 2012. For 2011, the concentration was low in Oyo West and Oyo East LGA.

Spill over effects (Getis and Ord)

The null hypothesis states that the spatial pattern is random across the study area.

The results from the G statistic for testing spatial dependence are given as follows: for 2011, G Index equalled 0.19, while the Z score equalled 0.93 standard deviations, with no apparent clustering detected at this scale. For 2012, the G index equalled 0.42 with a Z score of 6.21 standard deviations, with a less than 1% likelihood that the clustering of high values could be the result of random chance (see also Table 8).

Hotspots (Getis and Ord)

There were no hotspots for RTC as a result of human factors in 2011 (Figure 25). In 2012, the hotspots for RTC as a result of human factors include Oluyole, Ona Ara, Egbeda, Lagelu, Ibadan North, Ibadan North East, Ibadan North West, Ibadan South East, and Ibadan South West LGAs (see Figure 26).

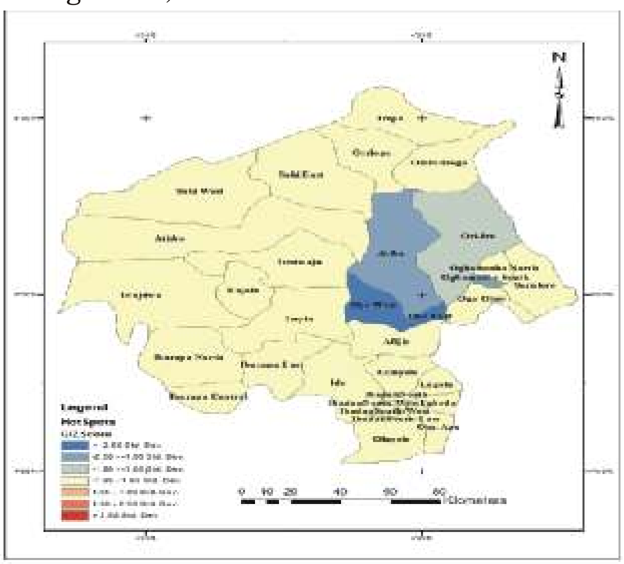


Figure 25: *Geovisual presentation of hotspots for Human Factor in 2011 (Getis and Ord)*

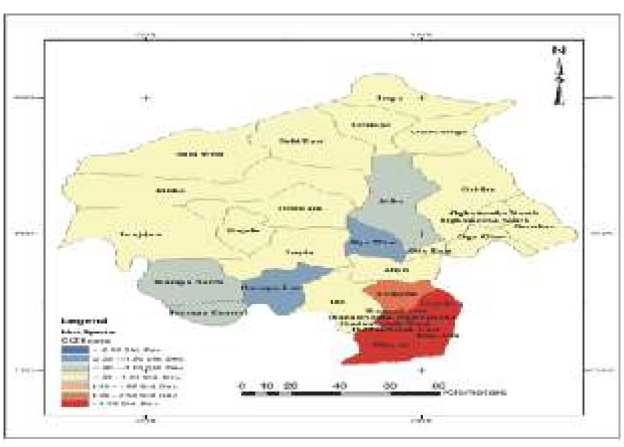


Figure 26: *Geovisual presentation of hotspots for Human Factor in 2012 (Getis and Ord)*

Table 8: *Getis and Ord Spatial Dependence for Human Factors among Local Government Areas: Number of Human Factors in Oyo State, 2011-2012*

(HIGHEST POSITIVE VALUES)

YEAR, 2011			YEAR, 2012		
LGA	G_i Z Score	G_i P value	LGA	G_i Z Score	G_i P value
Oluyole	1.548	0.122	Oluyole	4.661	0.000
None	None	None	Ona Ara	4.177	0.000
None	None	None	Egbeda	4.177	0.000
None	None	None	Ibadan North East	3.718	0.000
None	None	None	Ibadan North West	3.718	0.000
None	None	None	Ibadan South East	3.718	0.000
None	None	None	Ibadan South West	3.718	0.000
None	None	None	Ibadan North	3.296	0.000
None	None	None	Lagelu	2.630	0.008

High positive values for the normalized Z values for the G Statistic were observed in Oluyole, Ona Ara, Egbeda, Ibadan North East, Ibadan North West, Ibadan South East, Ibadan South West, Ibadan North and Lagelu LGA in 2012. The concentration was only high in Oluyole LGA for the year 2011.

DISCUSSION

Over 80 percent of the 1.3 million people killed by RTC and the 50 million injured on the worlds roads annually are adjudged to come from developing countries, with Africa having the highest death rate. The WHO predicted that if nothing is done by countries to stem the tide, deaths by RTC would increase by 65% from 2015 to 2020, overtaking malaria and tuberculosis [2]. Just as indicated by the WHO, results of this study showed no significant improvement on the incidence of RTC cases for the two periods investigated. As a result, the total casualties, namely, deaths and injuries, were notably high in 2012 for some LGAs when compared to total casualties in 2011.This suggests the need to intensify efforts that can promote safety and security measures on road networks in the state.

Again, RTI were estimated to be the eighth leading cause of death globally and described as the leading cause of death for young people aged 15–29 years. This, takes a heavy toll on those entering their most productive years. Economically disadvantaged families are hardest hit by both direct medical costs and indirect costs such as lost wages that result from these injuries. This is because the enormous toll exacted by RTI had for many years been neglected by global health and development agendas [3]. The WHO also asserts that more than half the people killed in traffic crashes are young adults aged between 15 and 44years often the bread winners in a family [1]. The findings support existing literature on RTC deaths and RTI as growing health issues disproportionately affecting vulnerable groups of road users, including the poor [2,5,7,9,10]. In the present study there was very high indication that more males sustain injuries than females as a result of RTC. For the two periods, the number of males and adults that sustained injuries was high, when compared to the number of females and children. Also, the study, gave a very strong indication that more male adults die as a result of RTC. For instance, the number of adults (blue) killed in 2011 and 2012 was higher than the number of children killed (yellow). Again, the number of males and adults killed as a result of RTC was high, when compared to the number of females and children killed. Male adults' death could impact negatively on the families, work force of the nation and invariably cause a reduction in the GDP. Thus, increased focus on deaths and injury prevention policies is required to stem the trend.

In the studies of Plasencia and Borrell [5], Leveque et al [6], Cirera et al [7] and Labinjo et al [8], marked differences were observed across districts and temporal variations recorded in respect of investigations on deaths and injuries resulting from RTC cases. In a similar vein, this study observed geographic and temporal disparities on the causes and characteristics of RTC, deaths and injuries. One of the several causes of RTC is dangerous driving. Considering the two periods investigated, the null hypothesis of randomness was rejected. Based on Moran's and Getis and Ord's statistics, we conclude that the spatial pattern is clustered, that is, there is spill over effects of dangerous driving within particular LGAs across the State. The hotspots are Oyo West, Oyo East, Afijio, Atiba and Ibarapa East LGAs. The study observed the road network within these LGAs is one way route from Oyo through to Ogbomoso town; some parts have sharp bends; most parts have potholes and the asphalt on some parts are no longer regular and smooth. As a result, once a driver makes a wrong attempt to overtake it leads straight to head on collision because there are no side routes or lay bays to hide for both the dangerous careless driver and the innocent careful one maintaining the right lane. Furthermore, the state of the road makes it very easy for vehicles to swerve off the main road when a driver over speeds or losses control. The spill over effects indicated in the results is supported in reality; almost every portion of the road has an RTC record. This conforms to the FRSC RTC (2011/2012) records, when the land marks within these hotspots are observed very closely. The causes of RTC however, varied in other LGA but mostly not the result of wrongful overtaking as observed in these LGAs.

Next we focus on speed limit violation, for the two periods under study; the null hypothesis of randomness was rejected. Based on Moran's and Getis and Ord's statistics, we conclude that the spatial pattern is clustered, that is, there is spill over effects of speed limit violation within particular LGAs across the State. The hotspots are Oluyole, Ona Ara and Ibadan South East LGAs. The study observed the major road network (Ibadan-Lagos expressway) within Oluyole LGA had heavy traffic flow and drivers travelling at high speed. Ona Ara and Ibadan South East LGAs are contiguous to Oluyole LGA. As such the spill over effect makes these two LGAS prone to RTC. This road network is a busy long stretch; some parts have potholes, sharp bends and adjoining roads. Looking closely at the landmarks used by the FRSC in the RTC data, most RTC were observed close to T- junctions. This suggests RTC occurs when pedestrians attempt to cross the expressway or vehicles attempt to join the expressway. The attitude of drivers on this expressway could lead to losing control of the vehicle especially when there is an unexpected need to slam the brake.

With a special focus on mechanical fault were RTC is a result of brake failure and/or tyre burst. For the two periods under study, the null hypothesis of randomness is rejected. Again, based on Moran's and Getis and Ord's statistics, we conclude that the spatial pattern is clustered, that is, there is spill over effects of mechanical fault within particular LGAs across the State. The hotspots are Oluyole, Ona Ara, Lagelu, Ibadan South East and Egbeda LGAs. Oluyole (Ibadan-Lagos expressway) and Egbeda (Ife-Ibadan expressway) LGAs have major road networks with two routes and very heavy traffic, while Lagelu has a major road network (Ibadan - Iwo expressway), which has one route. However, Ibadan South East and Ona Ara LGAs are affected because of spill over effect; RTC in these areas is high because of the frequencies of

RTC in the contiguous LGAs within the state. Although, a few of the RTC cases were the result of dangerous driving, speed limit violation and human factors but the main cause in majority of the RTC cases in these LGAs is mechanical fault. Increased vehicle inspection in these LGAs could promote safety and security on the roads.

Lastly, human factors, categorized as driving under alcohol influence, overloading, obstruction or bad road could cause RTC. For the two periods under study, the null hypothesis of randomness is rejected. Based on Moran's and Getis and Ord's statistics, we concluded the spatial pattern is clustered, that is, there is spill over effects of human factors within particular LGAs across the State. The hotspots are Oluyole, Ona Ara, Egbeda, Lagelu, Ibadan North, Ibadan North East, Ibadan North West, Ibadan South East, and Ibadan South West LGAs. It is evident that each of these LGAs is contiguous to at least one other LGA in the group. Another unique feature of these hotspots is high traffic volume and population density in the LGAs. Again, there are major road networks across these LGAs, most of which are in the heart of the state. Moreover, the study observed serious business activities along these routes, for instance markets, garages, schools, filling stations, banks and hospitals are some basic features that attract people and can be described as trip generators which indirectly generate RTC. Drivers attitude, therefore need to be put under control to ensure security of lives and properties.

In summary, RTC in Oyo State are characterized by deaths of male adults and the same group of persons get injured. This category of adults is likely to be young adults, probably bread winners of their families. Results show there is spill over effect of causes of RTC around particular LGAs. The concentration of RTC for the hotspots is high indicating spatial dependence. This suggests that safety and security measures must be administered across the hotspots simultaneously in order to achieve significant remedial effect. Apparently, RTC are mostly the result of drivers' actions or inactions, thus, these attitudes can be tailored positively to enhance a reduction in the frequencies of RTC across the state's roads. Furthermore, there is a need to improve the conditions of road networks in the state if RTC cases must be reduced.

CONCLUSION

The results should enable the orientation of deaths and injury prevention policies targeted on the adult males in the state. This is because of the significance of young male adults in the society. In particular, deaths and injuries of young male adults have a significant effect on the workforce of the nation. This impacts negatively on economic activities and can indirectly cause a devaluation of the country's GDP. Due to the socio economic implication of losing young adults, further works could aim at investigating the age group of persons involved in RTC and the effect on the occupational structure. Also, the cost of traffic injuries to low income and middle income countries is a global issue of concern. This has been described as being higher than the total development aids received by these countries. As such, an investigation into the cost of RTC will provide a good guide to measure the negative effect on the society.

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