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Roadway Environmental Conditions and Road Traffic Crash Occurrence, Injury and Death in Oyo State, Nigeria

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Abstract. The road mode remains the most integrated, accessible, and widely utilised form of global transportation. However, it presents significant challenges to global health and safety due to traffic crashes. While previous studies have often focused on the causative factors of traffic crashes, limited attention has been given to the influence of roadway environmental elements using GIS-referenced data, particularly in developing countries such as Nigeria. This study employs GIS and statistical methodologies to evaluate the impact of roadway environmental factors on road traffic crashes in Oyo State. Adopting an ex post facto research design, crash records from the Oyo State Federal Road Safety Corps (FRSC) for 2020–2022 were analysed. Attributes examined include date, time, location, crash type, causes, casualties, and weather conditions. Key findings reveal that roadway defects ($p = 0.001$), crash timing ($p = 0.007$), road surface condition ($p = 0.018$), and weather conditions ($p = 0.021$) significantly influence crashes. Binomial Logistic Regression shows that crashes involving partial road collapse, absence of road guards, fog, rainfall, and inadequate shoulders are 4.5, 3, 3, 2, and 2 times more likely to result in injuries than fatalities, respectively. Furthermore, Pearson Correlation indicates a moderate inverse relationship between roadway elevation and crashes ($r = -0.426$, $p < 0.01$). The study concludes that roadway environmental conditions significantly contribute to traffic crashes in Oyo State. It recommends frequent blackspot patrolling, redesign of high-risk locations, routine road inspections, maintenance of vulnerable segments, and improved signage to mitigate road traffic crashes in the area.

Keywords: Blackspot, Geo-reference, Crash Scene Light, Roadway Environment

1. Introduction

Transportation by road is the most available mode of transportation available to mankind. It provides services at door step level unlike other modes such as air, rail, maritime and pipeline as such road network is the most intensely utilised globally, effort to organise movements on the roadways lead to improvements such as tarred roads, markings and signage's among other rules and regulation that guides its safe operation. In spite of these efforts road traffic crashes (RTCs) represent a significant worldwide challenge causing substantial morbidity and mortality, "an average of 1.19 million people die each year from road traffic crashes globally" (WHO, 2023).

Movements along the roadway may be loosely divided into two categories; people and cargo, the categorisation of these movement types is ensured in many nations by permit requirements and safety laws. Just as a horse or an ox can go down a road, so can a car, truck or motorbike. While passengers may be transported by car or bus for mass transit, cargo can be delivered by trucking firms. Modern roadways are calibrated to accommodate these various types of movement and are often distinguished by well-marked lanes, signs and other roadway characteristics to enhance road safety. "Nigeria has the largest road network in West Africa, with a national network of roads currently estimated to be about 194,200 km of which 129,580 km (or 66.7%) are local and rural roads, 30,500 km (15.7%) are state-owned roads and the federal government owns 34,120 km (17.6%)" (Lamidi, et al 2022).

Although the road transport system is pivotal to economic progress and remains indispensable among transportation modes, it is also regarded as the most perilous and costly in terms of human lives lost (Raji and Solanke, 2013). This is due to the persistent occurrence of road traffic crashes (RTCs) in Nigeria, which have varied in magnitude over the years. Numerous factors have been identified as contributing to these incidents. Road traffic crash is a vehicular crash situation involving moving vehicles on the roadway, the vehicles could veer off the roadway into the immediate environment, resulting in injuries or deaths as well as causing damage to goods and property being transported (Al-Khaledi, et al (2022). World Health Organization (WHO, 2023) opined that "a traffic crash can also be explained as the road-vehicle-driver system failing to complete one or more tasks necessary for finishing a journey without causing any harm and damage to people and property respectively". Road crashes are mostly caused by inadequate upkeep of the road network, ineffective and irregular enforcement of traffic laws (Wang et al 2023).

2. Literature Reviews

Aslam et al. (2019) state that the goal of the current work is to identify accident hotspots utilising geographic information systems (GIS) and fuzzy logic in various places. Accident types and timing were among the information used. Spatial temporal analysis was used to study injury and fatality as well. In addition, by utilising the findings from the Analytic Hierarchy Process (AHP), accident hotspots were forecasted through the widely employed weighted overlay method (WOM) and the fuzzy overlay method (FOM). Both techniques are essential for informed decision-making and alternative analysis. The two approaches discussed above produced hotspots in an urban area, which were then verified using the point density (PD) method. Irbid City in Jordan's hot locations for traffic accidents were identified using data from accidents that happened between 2013 and 2016.

This study used traffic collision data from Houston, Texas, to explore factors impacting crash length and geo-statistical analysis. According to Xu and Wei (2018), there are 14 independent elements connected to time, the highway and the environment that might determine how long a road accident lasts.

The influence of traffic collisions, varying in severity, on the highway network was assessed by analyzing the delays caused by these incidents as a key indicator. Furthermore, ArcGIS kernel density analysis techniques were utilised to investigate the spatial distribution patterns of key impact factors under various conditions within the region. The integration of these two methodologies is both logical and practical for comprehensive analysis. The results reveal a higher likelihood of accidents occurring during nighttime and holiday periods.

Wesam et al. (2012) conducted an evaluation of traffic accidents in Amman by utilizing temporal and geographical frameworks to identify accident hotspot zones within the study area. To attain a thorough comprehension of the temporal distribution of accidents and to discern the most critical incidents according to a range of factors which includes the year of occurrence, accident severity, road type, and lighting conditions—they analysed the spatial distribution of accidents over a three-year period. By employing GIS-based statistical and spatial analytic techniques, they identified blackspots, which represent clusters with high concentrations of accidents.

The distribution pattern of traffic accidents was analysed using the Nearest Neighbour Index (NNI), focusing on specific characteristics. Alamirew et al. (2021) emphasised that identifying hazardous highway areas through spatial pattern analysis of collisions, as well as assessing crash linkages with surrounding regions and other pertinent factors, is essential for effective road safety practices. Over the years, safety experts have utilised diverse methodologies to assess historical road traffic crash (RTC) data via advanced GIS-based blackspot analysis. This study considered the severity levels of RTCs to analyse and rank areas identified as accident blackspots. Spatial autocorrelation tools in ArcGIS 10.5 were employed to investigate the geographical patterns of RTCs, while the Getis-Ord Gi* statistic was used to identify regions characterised by high and low severity crash clusters. The findings underscored the efficacy of this analytical approach.

Road traffic crashes are still prevalent in the sphere of human existence, both in developed and developing societies. The impact may vary but the casualties are the same, as it leads to the death and paralysis of people and the destruction of goods and properties. Many factors have been adduced by scholars across the world to be responsible for road traffic crash occurrences (Liu et al (2024), Al-Khaledi, et al (2022). These includes human behaviour and failure in the vehicular system; however, not much of the environmental factor is emphasised. Road traffic crashes remain a prevalent issue globally, significantly impacting both developed and developing societies. The casualties, including deaths and injuries, are a common consequence, with developing nations experiencing a higher fatality rate. Nigeria ranks 54th in the global index of road traffic crash with deaths reaching 41,693 (WHO, 2020).

Oyo State is located in the southwestern region of Nigeria, is no exception to this situation as it is ranked 4th in road traffic crash rankings Federal Road Safety Corps (FRSC 2023). The state's capital; Ibadan is one of the largest cities in Nigeria and a major transportation hub, contributing to the high volume of vehicular movement. There high fatality rate in developing world than in the developed countries is another question begging and waiting for answer with 20–27% of road traffic crash produces deaths of about 100,000 people, against the 4–9% death in developed world (WHO, 2020). What could be the source of this discrepancy in the casualty of road traffic crashes? It is common knowledge that the roadway environment in developing countries is not what it should be in terms of safety. Different factors that relate to the natural environment in which the roadway is situated calls for re-evaluation to produce an improved knowledge with regards to road traffic crash occurrences. Despite various factors such as human behavior and vehicle system failures being identified, the role of environmental factors is less emphasised.

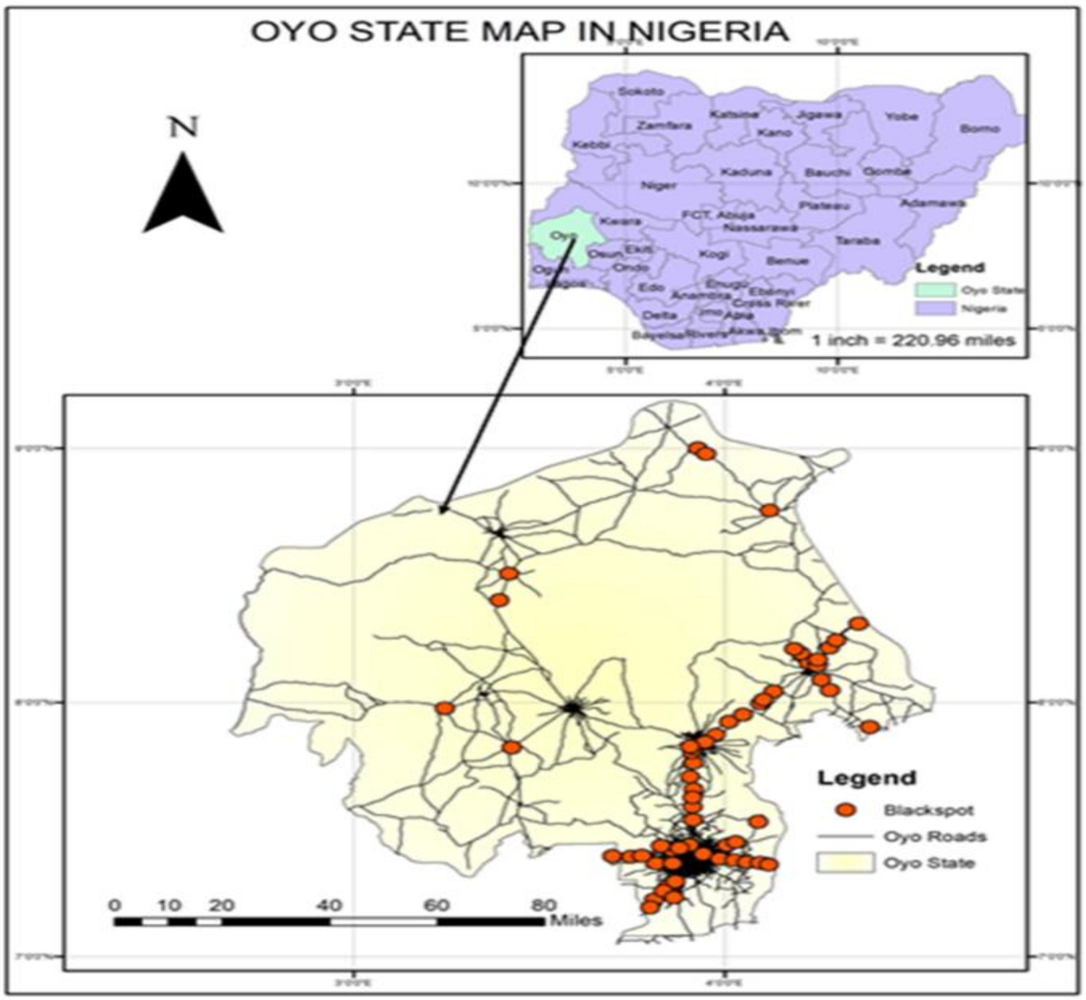

Fig: *Map of Oyo state showing the blackspots*

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1. Research Methodology

3.1 The Study Area

The approximate location of Oyo State is 7° 22' N and 3° 58' E on the Greenwich Meridian. That being said, the region, often known as the metropolitan area, lies between latitudes 7°15' and 7°30' north of the equator and longitudes 3°45' and 4°00' east of the Greenwich Meridian. It is located in the southwest of the nation and is bordered to the east, north, and south by Osun State, Lagos State, and Kwara State. Oyo State is one of the states that form the Nigerian Federation. It's around 145 kilometres northeast of Lagos. Lagos' most direct connection forms its western boundary with the Republic of Benin; nonetheless, the city is directly connected to several locations in Nigeria by a network of highways, trains, and air lines. Ibadan is a key break-bulk point for trading products from the southwest to the north and from the north to the southwest, and it is traversed by the railway that leads to the northern states.

Road Safety International 2020 states that, in the 1980s, when the Victorian blackspot programme began in Australia, a site had to have 12 fatalities in three years in order to be classified as a "blackspot." Today, that need is reduced to three fatalities in five years. A blackspot is an area where there are a lot of fatal, major, or minor collisions. It might be a stretch of road or a junction (road segment). The most crucial information used to achieve the accomplishments consists of: • Where the crash occurred (location) When (time) it happened (day/night) revealing scene light. The road users involved (causality level) Conditions at the time were rain, wind, fog, and sun. Roadway characteristic assessment

3.2 Research Design

Correlational and descriptive research design was employed for this investigation. This made it possible for the researcher to collect the necessary data, understand how road safety is managed, and identify any possible connection between the state of Oyo's traffic crashes and the state's road environment.

3.3 Data Gathering

This includes gathering feedback from the blackspot locations determined by the FRSC Oyo State Sector, as shown in Fig. 1. This research is primarily concerned with the roads that the FRSC covers in Nigeria's Oyo State in order to evaluate the state of the road in connection with determining the environmental factors that encourage traffic accidents along the different road segments. The Federal Road Safety Corps (FRSC) traffic collision database in Oyo state sector 2020–2022 served as the researcher's primary source of data. Georeferenced maps of Oyo State, road network maps, satellite images (Landsat and Google Maps), and data from road segments with identified traffic crash blackspots were collected during a field survey. These locations were measured, and the picked coordinates were recorded using a handheld GPS device to make them easy to recognise in a GIS environment.

3.4 Sources and Data Collection Instruments.

The data collection processes are as follows:

Personal Observation: The researcher conducted a field survey of the identified road segments in the study area in order to identify these road segments with traffic crash black spots, observe their unique physical properties, and create an attribute table for the various road segments.
Secondary Data: The data used for this study include the satellite imagery of Landsat and Google Earth with spatial resolutions of 30 and 5 metres, respectively, which were acquired and used to extract the route for the study area, the coordinates of the crash segments with the aid of GPS, and the crash record of the study area obtained from the Federal Road Safety Corps (FRSC) with the attribute data below:
Time of occurrence of crash
Location or route of the crash
Number of vehicles involved
Type of crash (fatal, severe, major, or minor)
Causes of the crash
The number of people involved in the crash

2. Results and Discussions

The table below shows the roadway environmental characteristics, sub-elements, number of crashes, injuries, deaths, and fatalities as reported by the FRSC.

The Roadway Environmental Factors and Roadway Traffic Crash.

Table 1: No of crash related to each environmental factors.

S/N	Environmental Factors	Condition	NO. RTC occurrences	No of injuries crash	No of death crash	Fatality
1	Crash Crash scene light	Day Sunrise	3571	1246	315	353
		Night Sunset	4995	1282	493	511
2	Weather:	Clear	384	168	50	58
		cloudy	282	112	38	54
		Foggy	4057	1484	380	398
		Stormy/rainy	3783	748	335	349
3	Roadway segment geometry.	4-way intersection	266	110	27	29
		Narrow single lane	962	155	92	95
		Roundabout	229	114	35	43
		Straight flat Up hill	47	424	182	43
		Straight/ curved road	87	35	7	7
4	Roadway surface condition:	Dry	229	114	35	43
		pot holes	29	12	4	4
		Wet	8308	2402	769	817
5	Roadway defect:	Defective/ No lighting	1947	627	139	141
		inadequate road shoulder	4669	1317	458	494
		Lack of standard road guard	15	5	4	4
		Partial road collapse	182	1706	465	172

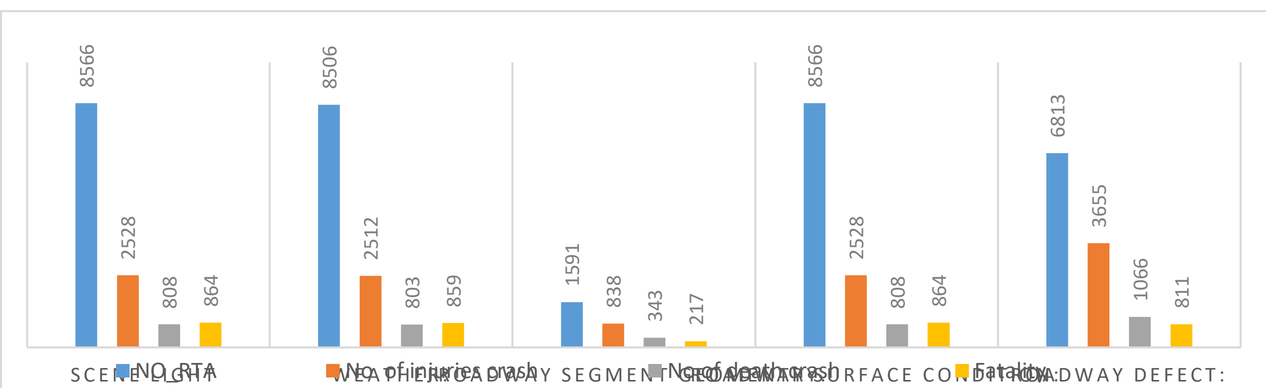

Fig: 2 Chart Bar showing crash related to each environmental factors

The chart in Fig. 2 shows that roadway defects produce the highest level of injury and death crashes, even with the second-lowest occurrence of roadway traffic crashes in the study area. Other influencers of roadway traffic crashes are the time of crash (scene light) and roadway surface condition, which have equal contributions to injuries and deaths. Roadway segment geometry has the lowest influence on causing roadway traffic crashes, with the lowest injuries and deaths associated. Weather is associated with the second highest roadway traffic crash occurrence and the third highest injury level of death crash.

The statistical assessment of the effect of roadway environmental factors on roadway traffic crash occurrences is to statistically evaluate the significance of the relationship between roadway traffic crash occurrence and roadway environment using multiple regression analysis.

2.1 Multiple Regression Analysis

Multiple regression is a statistical method used to examine the relationship between a dependent variable and two or more independent variables. It allows us to understand how the independent variables collectively relate to or influence the dependent variable. By controlling for the effects of other variables, multiple regression helps us identify which independent variables have a significant impact on the dependent variable and to what extent. According to Gulden, Kaya Uyanik and Nese Guier (2013) found that it can be used to assess the importance of the independent variable in a given regression equation. In this study, multiple regression is used with a view to finding out the level of importance or contribution of the independent variables (time of crash, roadway alignment, and roadway surface condition) to road traffic crash occurrence by analysing the beta coefficients to show the importance of each coefficient, as exemplified by Kaya Uyanik and Nese Guier (2013). The magnitude indicates the size of the impact that a specific independent variable has on the dependent variable. A larger absolute beta coefficient value suggests a stronger influence. While statistical significance is determined by the p-values associated with the beta coefficients. Multiple regression model is stated as below:

H_1: There is no significant impact of roadway environment factors on traffic crash occurrence.

Table 2 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.751a	.564	.430	.290	.564	4.203	4	13	.021

The R-value represents the correlation between the dependent and independent variables, which is.751, which implies that there is a 75.1% correlation between the dependent (roadway traffic crash occurrence) and independent variables, with the R square value at.564, meaning that the model explains 56.4% of the variance in road traffic crash occurrences. While the adjusted variable of.430 implies that 43% of the variance of the dependent variable is explained by the independent variables.

Table 3 Coefficients

Model	**Sum of Squares**		**df**	**Mean Square**	**F**	**Sig.**
1						
Regression	1.410		12	.352	4.203	.021
Residual	1.290		13	.084		
Total	2.500		17			

a. Predictors: (Constant), Roadway segment geometry. Roadway surface defect, Road Surface Condition, Time of crash b. Dependent Variable: Road traffic crash.

Important Model: We reject the null hypothesis because the p-value (0.021) is less than the standard alpha threshold of 0.05, which shows that at least one of the independent variables has a significant relationship with the dependent variable, indicating that the regression model strongly predicts the dependent variable. Overall Fit: The large F-value of F (4.13) = 4.203 suggests that the model accounts for a sizable percentage of the variation in the dependent variable (road traffic crash). The multiple regression model is statistically significant, as indicated by the ANOVA table, which suggests that the independent variables together offer a strong match for predicting the dependent variable at R square =.564, indicating that the model explains 56% of the variance in road traffic crash occurrence.

Table 4 Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B	
	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
(Constant)	.762	.508		1.500	.158	-.336	1.860
Time of crash	.634	.197	.851	3.219	.007	.209	1.059
Road Surface Condition	-.757	.279	-.677	-2.716	.018	-1.360	-.155
Roadway defect	.192	.048	1.060	4.005	.001	.088	.295
Roadway geometry	.039	.049	.159	.798	.439	-.067	.145
Weather condition	.211	0.38	1.099	3.061	.021	.071	.311

Dependent Variable: Road traffic crash.

The unstandardized coefficient, or B, is 0.762. This is the projected value of the dependent variable when all independent variables are zero, or the intercept of the regression line. 1.500 is the t-value. To see if the constant deviates noticeably from zero, use this value. P-value (signature): 0.158. This result indicates that the constant is not statistically significant because it is bigger than 0.05. Time of crash B: 0.634. Keeping all other factors fixed, the dependent variable is predicted to grow by 0.634 units for every unit increase in crash time.

The standardised coefficient, or beta, is 0.851. This suggests that there is a significant positive correlation between the dependent variable (road traffic crash occurrence) and the time crash t-value: 3.219. This figure determines whether the coefficient deviates noticeably from zero. Significance: 0.007. This number is less than 0.05, indicating statistical significance for the time of crash for B, the 95% confidence interval is 0.209–1.059.

Road surface condition, B: -0.757. The dependent variable (road traffic crash) is predicted to fall by 0.757 units for every unit increase in the road surface condition (assuming higher values imply poorer conditions), keeping all other factors constant. Beta is -0.677. This suggests that the dependent variable and road surface condition have a strong negative connection. t-value:-2.716. Significance: 0.018. The road surface condition is statistically significant because this value is smaller than 0.05. B's 95% Confidence Interval: -0.155 to -1.360.
Roadway defect: B: 0.192. Keeping all other factors equal, the dependent variable (road traffic crash) should rise by 0.192 units for every unit increase in highway defect. Beta is 1.060. This suggests that there is a highly significant positive correlation between the dependent variable and the roadway defect. 4.005 is the t-value. Significance: 0.001. Roadway defect is statistically significant since this value is smaller than 0.05. For B, the 95% confidence interval is 0.088–0.295.

Roadway geometry: B is 0.039. Keeping all other factors fixed, the dependent variable (road traffic crash) is predicted to rise by 0.039 units for every unit increase in roadway geometry. Beta: 0.159. This suggests that the roadway geometry and the dependent variable have a weakly positive correlation (t-value: 0.798). Significance: 0.439. The roadway geometry is not statistically significant, as this value is more than 0.05. -0.067 to 0.145 is the 95% confidence interval for B. Zero is included in this interval, confirming its absence of importance.
Weather Condition B is 0.211: Keeping all other factors fixed, the dependent variable (road traffic crash) is predicted to rise by 0.211 units for every unit increase in weather condition. Beta = 1.099: This suggests that there is a highly significant positive correlation between the dependent variable and the weather condition. 3.06 is the t-value: **Significance: 0.021:** The weather condition is statistically significant since this value is smaller than 0.05, for B = 95%. The confidence interval is 0.071–0.311.
Significant Predictors: The dependent variable (road traffic crash) may be statistically predicted by the time of the crash, roadway condition, and roadway defects. Non-Significant Predictors: There is no statistically significant correlation between the roadway geometry and the constant. Connections: The dependent variable (road traffic crash) has a positive correlation with the time of the crash, weather condition, and road defect. There is a negative correlation between the dependent variable (road traffic crash) and road surface condition. Repairing road imperfections and enhancing road surface conditions may have a big effect on road traffic crashes.

In testing the null hypothesis, which states that "there is no significant effect of roadway environment factors on traffic crash occurrence," looking at the elements of the roadway environmental factor, which are time of crash, road surface condition, Roadway defect, Roadway geometry and weather condition as the independent variables. We can conclude that there is significant evidence to reject the null hypothesis that states that there is no significant effect of roadway environment factors on traffic crash occurrence, and hence state that “there is a significant effect of roadway environment factors on traffic crash occurrence.”

Factors Causing High Odd of Death and Injuries Crash

There is no significant effect of the elements of roadway environmental factor on roadway traffic crash resulting to death and injuries.

Table 5: No of crash related to each environmental factors.

S/n	Elements	Factors	NO. RTC	injuries crash	death crash	Serious crash	minor Crash
1	Time of Crash	Day Sunrise	3571	1246	315	353	1657
		Night Sunset	4995	1282	493	511	2709
2	Weather:	Clear	384	168	50	58	108
		cloudy	282	112	38	54	78
		Foggy	1057	184	380	98	395
		Stormy/rainy	1783	748	335	349	351
3	Roadway segment geometry.	4-way intersection	266	110	27	29	100
		Narrow single lane	962	155	92	95	620
		Roundabout	229	114	35	43	37
		Straight flat Up hill	647	424	182	40	1
		Straight/ curved road	87	35	7	7	38
4	Roadway surface condition:	Dry	229	114	35	43	37
		pot holes	29	12	4	4	9
		Wet	817	84	169	308	256
5	Roadway defect:	Defective/ No lighting	1947	627	139	141	1040
		inadequate road shoulder	494	117	158	169	50
		Lack of standard road guard	15	5	4	4	2
		Partial road collapse	1706	182	465	172	887

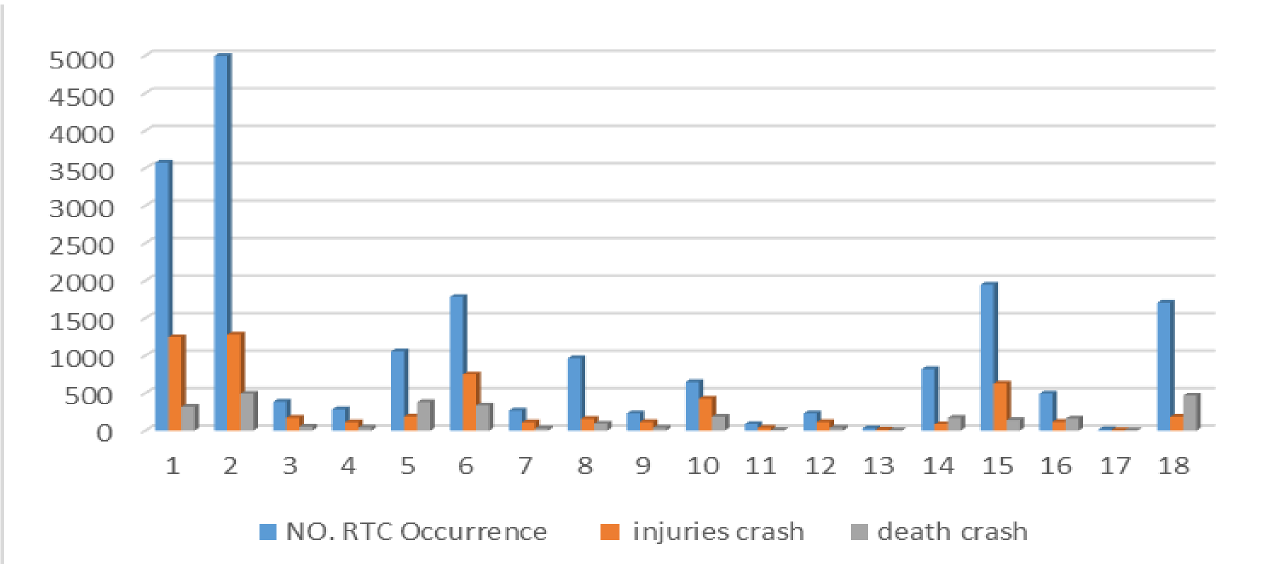

Fig.3:** Comparison of RTC Occurrences, Injury and Death Crashes.**

The blue bars represent the total number of Road Traffic Crash (RTC) occurrences. Element 2, 1,15,6 and 18 (Day Sunrise, Night Sunset, Defective/No lighting, Stormy/rainy and Partial road collapse) respectively having the highest occurrences frequency. The total number of RTC occurrence, RTC resulting in injuries are represented in orange bars. The peaks in injury crashes correspond to spikes in RTC occurrences, especially in element 1, 2, 6, and 15 (Night Sunset, Day Sunrise, Stormy/rainy, Defective/No lighting,) suggesting that these high-frequency crash areas or conditions also lead to a higher number of injuries. The gray bars represent crashes resulting in death which are consistently lower in magnitude compared to injury crashes more evident in categories such as 2, 18, 5, and 6. Day Sunrise, Partial road collapse, Foggy Stormy/rainy.

The hypothesis investigating the substantial link between roadway traffic crash fatalities (injuries and deaths) and roadway environment parameters was prompted by the knowledge that roadway environmental elements have a variety of effects on the fatality of road traffic crashes. A binomial logistic regression model was created to assess the odds and probability of the fatality of a crash under the combination of various roadway environmental factors, allowing the researcher to determine which of the component variables of the roadway environment factors in this study contributes the most to the fatality of roadway traffic crashes (death and injuries)

4.2 Binomial Logistic Regression.

Table 6: Predictors' Unique Contributions in the binomial Logistic Regression

Predictor	x	df	p-value
Time of crash	0.005	1	0.94
Weather	2.173	1	0.34
Road Segment alignment	1.773	1	0.18
Road Surface Condition	0.096	1	0.76
Roadway Defect	1.425	1	0.53

From the predictor table 4.10, it is observed that the roadway environmental factors predators have no significant association with roadway traffic crash fatalities. However, with further investigation into the elements within these environmental factors, applying multinomial logistic regression, we are able to ascertain the odds of death and injury fatalities shown in Table 6.

Binomial logistic regression is used when the outcome variable is not more than two categories of predictors, These odds ratios compare the odds of an event occurring (roadway traffic crash) given a factor to the odds of an event occurring in the absence of that factor. The fatality of a road traffic crash in this study is defined by the number of deaths and injuries in a crash at a given location and at a particular time. Each coefficient βi represents the change in the log odds of the dependent variable being 1 for a one-unit change in the corresponding predictor Xi, holding all other predictors constant. The odds ratio can be computed as $e^{\beta i}$. An odds ratio greater than 1 indicates an increase in the odds of the outcome with an increase in the predictor, while an odds ratio less than 1 indicates a decrease.

Table 7: Coefficients of factors on road traffic crash fatality

Factor	Coefficient (β)	Odds Ratio (OR)
Night Sunset	0.5	e0.5≈1.65e^{0.5} \approx 1.65e0.5≈1.65
Cloudy	0.2	e0.2≈1.22e^{0.2} \approx 1.22e0.2≈1.22
Foggy	1.0	e1.0≈2.72e^{1.0} \approx 2.72e1.0≈2.72
Stormy/Rainy	0.7	e0.7≈2.01e^{0.7} \approx 2.01e0.7≈2.01
Narrow Single Lane	0.3	e0.3≈1.35e^{0.3} \approx 1.35e0.3≈1.35
Roundabout	0.1	e0.1≈1.11e^{0.1} \approx 1.11e0.1≈1.11
Straight Flat Up Hill	0.6	e0.6≈1.82e^{0.6} \approx 1.82e0.6≈1.82
Straight/Curved Road	-0.1	e−0.1≈0.90e^{-0.1} \approx 0.90e−0.1≈0.90
Pot Holes	0.4	e0.4≈1.49e^{0.4}\approx 1.49e0.4≈1.49
Wet	0.5	e0.5≈1.65e^{0.5} \approx 1.65e0.5≈1.65
Inadequate Road Shoulder	0.7	e0.7≈2.01e^{0.7} \approx 2.01e0.7≈2.01
Lack of Standard Road Guard	1.2	e1.2≈3.32e^{1.2} \approx 3.32e1.2≈3.32
Partial Road Collapse	1.5	e1.5≈4.48e^{1.5} \approx 4.48e1.5≈4.48

Time of Crash with regards to Night Sunset (OR = 1.65), deaths crashes occurring during Night Sunset are 1.65 times more likely to result in death compared to those occurring during Day Sunrise. This indicates that night-time conditions might be more hazardous, leading to more severe outcomes. However, injuries conversely, crashes during Night Sunset are less likely to result in injuries compared to Day Sunrise. This suggests that while night-time crashes are less frequent, they tend to be more severe when they do happen.

In the case of the Weather, Cloudy (OR = 1.22), deaths crashes occurring in cloudy weather are 1.22 times more likely to result in death compared to clear weather. Cloudy conditions might reduce visibility or make road conditions slightly more dangerous. In the case of injuries crashes in cloudy weather are less likely to result in injuries compared to clear weather. This indicates that crashes in cloudy conditions are somewhat more severe.

For Foggy (OR = 2.72), deaths crashes occurring in foggy conditions are 2.72 times more likely to result in death compared to clear weather. Fog significantly reduces visibility, leading to more severe accidents. Injuries crashes in foggy conditions are much less likely to result in injuries compared to clear weather. This shows that foggy conditions greatly increase the severity of crashes.

While stormy/Rainy (OR = 2.01), deaths crashes occurring in stormy or rainy conditions are 2.01 times more likely to result in death compared to clear weather. Wet and slippery roads contribute to more severe accidents. While injuries crashes in stormy or rainy conditions are less likely to result in injuries compared to clear weather, indicating a higher severity of crashes.

Whereas roadway segment geometry, narrow single lane (OR = 1.35), deaths crashes occurring on narrow

single lanes are 1.35 times more likely to result in death compared to those occurring at 4-way intersections. Narrow lanes can be more dangerous due to limited space for maneuvering. Injuries crashes on narrow single lanes are less likely to result in injuries compared to 4-way intersections. This implies that crashes on narrow lanes tend to be more serious.
With regards to roundabout (OR = 1.11), deaths crashes occurring in roundabouts are 1.11 times more likely to result in death compared to 4-way intersections. Roundabouts might cause confusion, leading to more severe crashes. Injuries crashes in roundabouts are slightly less likely to result in injuries compared to 4-way intersections, suggesting a slightly higher severity.

For a straight flat uphill (OR = 1.82), deaths crashes occurring on straight flat uphill segments are 1.82 times more likely to result in death compared to 4-way intersections. The higher speeds possible on these segments can contribute to more severe crashes. Injuries crashes on straight flat uphill segments are less likely to result in injuries compared to 4-way intersections, indicating a higher severity of crashes.

Relating with straight/curved road (OR = 0.90), deaths crashes occurring on straight or curved roads are 0.90 times as likely to result in death compared to 4-way intersections, meaning they are less likely to be fatal. Injuries crashes on straight or curved roads are more likely to result in injuries compared to 4-way intersections, suggesting that these crashes are less severe.

Concerning roadway surface condition, Pot Holes (OR = 1.49): Deaths crashes occurring on roads with pot holes are 1.49 times more likely to result in death compared to those occurring on dry roads. Pot holes can cause vehicles to lose control, leading to severe crashes. Injuries crashes on roads with pot holes are less likely to result in injuries compared to dry roads, indicating a higher severity of crashes.

In the case of wet road condition (OR = 1.65), deaths crashes occurring on wet roads are 1.65 times more likely to result in death compared to dry roads. Wet roads can be slippery and increase the likelihood of severe crashes. While Injuries: Crashes on wet roads are less likely to result in injuries compared to dry roads, suggesting that crashes in wet conditions are more severe.

Regarding roadway defect, inadequate Road Shoulder (OR = 2.01), deaths crashes occurring on roads with inadequate road shoulders are 2.01 times more likely to result in death compared to roads with no defects. Lack of proper shoulders can prevent safe recovery if a vehicle goes off the road. Injuries crashes on roads with inadequate road shoulders are less likely to result in injuries compared to roads with no defects, indicating higher severity.

About lack of standard road guard (OR = 3.32), deaths crashes occurring on roads lacking standard road guards are 3.32 times more likely to result in death compared to roads with no defects. Road guards prevent vehicles from veering off the road or into oncoming traffic. Injuries crashes on roads lacking standard road guards are significantly less likely to result in injuries compared to roads with no defects, indicating much higher severity.

In the case of partial road collapse (OR = 4.48), deaths crashes occurring on roads with partial road collapse are 4.48 times more likely to result in death compared to roads with no defects. Road collapses can cause severe crashes due to sudden loss of road structure. Injuries crashes on roads with partial road collapse are substantially less likely to result in injuries compared to roads with no defects, indicating extremely high severity.

3. Conclusion

Like in most cities across the world and in Oyo State, Nigeria the task of ensuring roads are safe is enormous road infrastructures lack functional street lights, road signs and symbols, road markings, etc., which must be put in place to ensure these roads do not become death traps for the user. The current road traffic crash situation is less desirable and urgent steps must be taken to reduce the rate of traffic crash occurrence and the associated severity. This study investigated roadway environmental element and road traffic crashes in Oyo State. The study achieved several objectives and revealed several critical issues relating to road traffic crashes in Oyo State.

Based on the results from the field, roadway environmental element (time of crash, roadway surface condition and roadway defect.) have a significant relationship with road traffic crash occurrences in Oyo State.

The study investigated the correlation between various roadway environmental element and road traffic crashes on 18 routes known to have blackspots. The analysis identified several key factors that significantly affect the likelihood of crashes. In particular, the timing of crashes was found to have a considerable impact, with a p-value of 0.007, indicating strong statistical significance. The beta values for this factor ranged from 0.634 to 0.757 showing a substantial effect size. With type of result day time driving is encouraged as night driving is very risky because of the danger posed by the immediate roadway environment that is always dark.

Road Surface Condition this factor had a p-value of 0.018, highlighting its significant role in crash occurrences. Poor road surface conditions contribute to higher crash rates as movement of the vehicle is made difficult which result to the vehicle losing its tyres, veering off the roadway or can collide with another vehicle while trying to avoid a pothole. Defects such as partial road collapse had an odds ratio (OR) of 4.48 lack of standard road guards had an OR of 3.32 and inadequate road shoulders had an OR of 2.01. These defects significantly increase the likelihood of crashes, with p-values of 0.001. These defects are as a result of the fact that the roads were not build to meet the required international standards safety wise.

Adverse weather conditions also played a crucial role, with fog having an OR of 2.72 and stormy or rainy conditions having an OR of 2.01. The p-value for weather conditions was 0.021, indicating a significant correlation. These conditions reduce visibility while driving as such movement on the roadway at such times should not be encouraged. Surprisingly, roadway geometry did not have a significant impact on crash occurrences in this study.

The study's analysis revealed that certain roadway defects and adverse weather conditions significantly increased the odds of death and injuries crashes. For instance, partial road collapse increased the odds by 4.48 times, lack of standard road guards by 3.32 times and inadequate road shoulders by 2.01 times. Similarly foggy conditions increased the odds by 2.72 times and stormy or rainy weather by 2.01 times. These elements are seen to increase the likeness of a crash situation resulting to deaths or injuries, factor relating to roadway surface condition leads followed by roadway defect factors and lastly weather conditions. The high odds ratios associated with roadway defects indicate a pressing need for infrastructure improvements. Authorities should prioritise repairing partial road collapses, installing standard road guards and ensuring adequate road shoulders to enhance roads safety.

Adverse weather conditions, particularly fog and stormy or rainy weather significantly increase the likelihood of fatal crashes. Implementing weather-responsive measures such as enhanced road lighting, reflective road markings and real-time weather updates for drivers could mitigate these risks.

4. Recommendations

The Federal Road Safety Corps (FRSC) is the government agency with the responsibility to ensure the roads are safe. However, the traffic crash situation remains significantly below acceptable standards. Based on the findings of this study, the following recommendations are made for the effective and efficient management of road safety in the study area:

- The government should empower the road safety corps to enhance better patrol of the blackspot locations.
- There is a need to put in place roadway lighting to illuminate the roadway and its surroundings, as most of the road segments where black spots were discovered lacked this infrastructure.
- Implementing weather-responsive measures such as enhanced road lighting, reflective road markings and real-time weather updates for drivers could mitigate these risks.
- Identified high-risk locations should be prioritised for safety interventions through the reconstruction, redesign, and resurfacing of roadways to improve their safety and functionality in all seasons.
- Engineering solutions such as better guardrails and road leveling could be considered

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