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TRENDS, PATTERNS, AND DETERMINANTS OF ROAD TRAFFIC ACCIDENTS IN NORTH-WEST NIGERIA: A LONGITUDINAL ANALYSIS (2016–2024)

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ABSTRACT

Road traffic accidents (RTAs) represent a critical public health challenge in Nigeria, with the North-West region experiencing a disproportionate burden due to its role as a major commercial corridor. This study provides a comprehensive statistical analysis of RTA trends, patterns, and severity across the seven states of North-West Nigeria from 2016 to 2024. Methods utilizing official data from the Federal Road Safety Corps, we employed descriptive statistics, two-factor analysis of variance, and post-hoc tests to analyze accident frequency, injuries, fatalities, and people involved. We computed casualty severity indices and fatality rates to assess accident severity across states. Results from the analysis revealed a dramatic surge in RTAs in 2024, with Kaduna State bearing the highest burden in absolute terms (7,804 crashes, 4,348 deaths). However, Katsina and Zamfara recorded the highest fatality rates (0.64), indicating more deadly crashes. A significant interaction effect ($p<0.001$) between states and crash metrics confirmed distinct state-specific accident profiles. The casualty severity index exceeded 50% across all states, peaking in Sokoto at 68%. Conclusion North-West Nigeria faces an escalating RTA crisis with substantial variations in accident patterns across states. The findings underscore the necessity for targeted, state-specific interventions rather than uniform regional approaches. Recommendations include enhanced data collection, infrastructure improvements, and coordinated multi-agency responses to address this public health emergency.

Keywords: Road Traffic Accidents, North-West Nigeria, Statistical Analysis, Accident Severity, Public Health

INTRODUCTION

Road traffic accidents (RTAs) represent a critical global public health challenge, causing approximately 1.19 million deaths annually worldwide, with over 90% of these fatalities occurring in low- and middle-income countries (Govender & Masanabo 2025). Nigeria, as Africa's most populous nation, bears a substantial portion of this burden and has been noted for its high road crash rate, with its North-West geopolitical zone being of particular concern due to its role as a major hub for inter-state commerce and transit. This region, comprising seven states (Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, and Zamfara), experiences high-density vehicular movement between northern and southern Nigeria and across international borders to the Niger Republic. The socio-economic impact of RTAs is profound, draining national resources through medical costs, lost productivity, and long-term care for survivors with disabilities (Inah *et al*, 2025). The North-West region presents unique challenges for road safety, including poor infrastructure, inadequate signage, vehicle overloading, mechanical deficiencies, and reckless driving behaviors such as speeding, which is consistently identified as a primary causative factor (Inah *et al*, 2025). Additionally, the deteriorating security situation involving banditry and kidnapping has indirectly influenced travel patterns and road safety, potentially leading to riskier driving practices and under-reporting of incidents, a known issue in many low- and middle-income countries where police data often capture a fraction of actual casualties (Wole *et a*l, 2024). Despite the apparent severity of the problem, a significant gap exists in context-specific empirical analysis of RTA trends within the North-West region over an extended period that captures pre-, during, and post-COVID-19 pandemic patterns alongside escalating security concerns (Wole *et a*l, 2024).

The global literature on road traffic accidents has identified multiple risk factors and prevention strategies. Ibrahim & Onyeka (2017) the World Health Organization emphasizes the Safe System approach, which acknowledges human vulnerability and aims to create a forgiving transport system through safe roads, safe speeds, safe vehicles, and safe road users

This approach recognizes that human error is inevitable, but fatal consequences are not.

In the Nigerian context, several studies have explored various dimensions of road traffic accidents. Ibrahim, Abubakar, and Suleiman (2020) analyzed trends in Northwestern Nigeria and identified speeding as the leading cause of accidents, with commercial vehicles being disproportionately involved and young adult males being the most affected group. Similarly, Salihu, Ojo, and Adekunle (2022) conducted a systematic review of causative factors in Nigeria and confirmed that human factors, particularly speeding, traffic rule violations, and driver distraction, are the predominant causes, exacerbated by vehicular factors like mechanical defects and environmental factors such as poor road conditions.

Methodologically, researchers have employed various approaches to understand accident patterns. Bello and Umar (2021) demonstrated the effectiveness of machine learning algorithms, particularly Random Forest, in predicting accident likelihood in Nigeria, with speed violation, road condition, and time of day as the most important predictive features. Elsewhere, studies have utilized black spot analysis to identify high-risk locations, with techniques ranging from accident frequency analysis to more sophisticated statistical methods like Poisson distribution and Bayesian approaches. These methods allow for targeted interventions at sites with statistically significant accident concentrations.

A growing body of research also addresses the intersection of security and road safety. Okoro, Yusuf, and Lawal (2024) found that security challenges in Northern Nigeria have led to riskier driving practices, including speeding through insecure areas and traveling in convoys, subsequently increasing

accident likelihood while simultaneously causing underreporting due to fear of attacks.

However, a critical limitation in the existing literature is the lack of longitudinal analyses that capture recent trends across all North-West states, particularly one that examines both the frequency and severity of accidents while accounting for state-specific variations. This study aims to fill this gap by providing a comprehensive statistical analysis of reported RTA cases in North-West Nigeria between 2016 and 2024, offering an evidence-based foundation for targeted interventions.

MATERIALS AND METHODS

This study employed a longitudinal analytical design to examine road traffic accident patterns in North-West Nigeria from the first quarter of 2016 to the third quarter of 2024. Data were extracted from the Federal Road Safety Corps (FRSC) Statistical Bulletin 2024, the primary official source for road traffic accident records in Nigeria. The FRSC operates a standardized nationwide data collection system through accident report forms completed by officers at crash scenes, ensuring consistency in data elements across states and over time. The study population comprised all reported road traffic accidents in the seven states of North-West Nigeria: Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, and Zamfara. The sample included complete quarterly data on four key metrics: Road Traffic Crashes (RTC), Number Injured (NI), Number Killed (NK), and People Involved (PI) from Q1 2016 to Q3 2024.

The method of data analysis used in this research is descriptive statistic and two factor analysis of variance.

Two Factor Analysis of Variance

Factorial design was also used to analyze the reported cases of road traffic casualty in Nigeria. The researchers intend to test for significant mean difference in the reported cases of road traffic casualties (number killed and number injured) in the six geopolitical zones. According to (Oyeka, 2013), a two-factor analysis of variance model comprising of factor A and B with interactions between these two factors, given as:

$$y_{ilj}=\mu+\propto_i+\beta_j+\lambda_{lj}+e_{ilj} \quad (1)$$

Where

y_{ilj} is the i^{th} observation at the l^{th} level of factor A and j^{th} level of factor B;

μ is the overall mean,

$\propto_i$ is the effect of the l^{th} level of factor A,

β_j is the effect of j^{th} level of factor B;

λ_{lj} is the interaction effect between the l^{th} level of factor A and j^{th}level of factor B;

e_{ilj} are the independent and normally distributed error which has constant variance,

for $i=1,2,..,nij$, $l=1,2,...a$, the "a" levels of factor A; $j=1,2,...b$ the "b" level of factor B, subjects to the constraints:

$\sum_{l=1}^{a} \propto_i = \sum_{j=1}^{b} \beta_j = \sum_{l=1}^{a} \lambda_{lj} = \sum_{j=1}^{b} \lambda_{lj} = 0$

The layout of two factorial design is given as below:

Table 1: ANOVA Table for Two Factor Classification)

Source of Variation	DF	SS	MS	F – Ratio
A	(a-1)	SS_A	$MS_A=\frac{SS_A}{(a\text{-}1)}$	$F_A=\frac{MS_A}{MS_E}$
B	(b-1)	SS_B	$MS_B=\frac{SS_B}{(b\text{-}1)}$	$F_B=\frac{MS_B}{MS_E}$
AB	(a-1)(b-1)	SS_{AB}	$MS_{AB}=\frac{SS_{AB}}{(a\text{-}1)(b\text{-}1)}$	$F_{AB}=\frac{MS_{AB}}{MS_E}$
ERROR	ab(r-1)	SS_E	$MS_{error}=\frac{SS_E}{ab(r\text{-}1)}$	
TOTAL	abr – 1	SS_T		

Sum of Squares

$$SS_A=\frac{\sum_{l=1}^{a} T_{l..}^2}{br} - CF$$

$$CF=\frac{T^2_{...}}{abr}; \quad SS_B=\frac{\sum_{j=1}^{b} T_{j..}^2}{ar}; \quad SS_{AB}=\frac{\sum_{l=1}^{a}\sum_{j=1}^{b} T_{lj}^2}{r} - CF - SS_A - SS_B$$

$$SS_{error}=SS_T - SS_{AB} - SS_A - SS_{AB}; \quad SS_{total}=\sum_{i\text{-}1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{r} Y_{ijk} - CF$$

Descriptive Statistics

The study employed descriptive statistic to compute the average and ratios among crash metrics.

The annual average Road Traffic Crash (RTC), Number of people Injured (NI), Number of people killed (NK) and number of people involved (PI) were computed as follows:

$$2016=\frac{Q_1+Q_2+Q_3+Q_4}{4}$$

The same computation was carried out for the remaining years except 2024 where the data was available for three quarters and was computed as:

$$2024=\frac{Q_1+Q_2+Q_3}{3}$$

The average quarterly crash metrics (RTC, NI, NK and PI) by state were computed as:

$$Jigawa\ (Q_1)=\frac{2016Q_1+2017Q_1+...+2024Q_1}{9} \quad (2)$$

$$Jigawa\ (Q_2)=\frac{2016Q_2+2017Q_2+...+2024Q_2}{9} \quad (3)$$

$$Jigawa\ (Q_3)=\frac{2016Q_3+2017Q_3+...+2024Q_3}{9} \quad (4)$$

$$Jigawa\ (Q_4)=\frac{2016Q_4+2017Q_4+...+2023Q_4}{8} \quad (5)$$

The fourth quarter stops at 2023. This is because the fourth quarter data was not available for 2024.

The same computation was carried out for the remaining states (Kaduna, Kano, Katsina, Kebbi, Sokoto and Zamfara).

The causality severity index (CSI) was computed as;

$$CSI=\frac{NI+NK}{PI}$$

The fatality rate (FR) was computed as:

$$FR=\frac{NK}{RTC}$$

Where

NI = Number of people injured

NK = Number of people killed

PI = Number of people Involved

RTC = Road Traffic Crash

RESULTS AND DISCUSSION

Temporal Trends in Road Traffic Accidents

The analysis revealed concerning trends in road traffic accidents across North-West Nigeria between 2016 and 2024. While fluctuations occurred throughout the period, a dramatic

and unprecedented surge was observed in 2024 across all seven states. Kaduna State consistently recorded the highest annual averages of road traffic crashes from 2016 to 2023, but in 2024, all states experienced substantial increases, with Kaduna's average skyrocketing to 832.7 crashes per quarter more than four times its 2023 average.

Table 2: Annual Average of Road Traffic Crashes (RTC) by State (2016-2024) was Extracted from Federal Road Safety Statistical Bulletin

Year/State	Jigawa	Kaduna	Kano	Katsina	Kebbi	Sokoto	Zamfara
2016	36.0	178.8	97.5	61.8	36.3	30.5	41.0
2017	54.5	188.8	75.8	62.5	38.3	22.8	25.3
2018	90.3	207.5	89.0	70.8	34.8	28.5	32.0
2019	56.8	189.0	75.5	73.8	46.5	34.3	33.8
2020	59.3	189.8	76.0	63.3	64.8	32.3	32.3
2021	88.3	207.3	69.8	34.5	53.3	30.5	33.3
2022	129.0	193.8	101.8	32.3	48.0	35.8	28.5
2023	116.0	180.3	77.3	32.8	35.8	23.5	21.0
2024	390.0	832.7	269.7	137.3	167.7	119.0	72.3

The patterns for injuries and fatalities showed similar concerning trends, though with some variations. Kaduna and Jigawa consistently bore the highest burden of injuries throughout the study period. Notably, for most states, the peak in injuries occurred in 2022 rather than 2024, suggesting a potential shift in the nature of accidents in the most recent year.

State-wise Comparisons and Seasonal Variations

Analysis of quarterly averages revealed distinct seasonal patterns in road traffic accidents across North-West Nigerian states (Table 2). The first quarter (Q1) emerged as particularly severe across most states, including Jigawa, Kaduna, Kano, and Katsina. This period coincides with the harmattan season, characterized by reduced visibility due to dust haze. Jigawa exhibited a unique peak in the third quarter (Q3) for crashes, injuries, and people involved, suggesting a strong influence of rainy season conditions or agricultural activities.

Table 3: Average Quarterly Crash Metrics by State (Q1 2016 - Q3 2024)

State	Quarter	Avg RTC	Avg NI	Avg NK	Avg PI
Jigawa	Q1	113.9	317.6	36.6	485.1
Kaduna	Q1	359.1	892.9	156.1	1768.6
Kano	Q1	126.0	366.3	62.3	691.1
Katsina	Q1	70.8	257.3	43.9	434.3
Kebbi	Q1	70.8	174.3	26.3	286.9
Sokoto	Q1	48.3	115.0	22.8	193.9
Zamfara	Q1	41.1	144.1	26.1	243.8

Kaduna State consistently recorded the highest accident burden every quarter, with Q1 being particularly severe. In contrast, Zamfara and Sokoto showed their highest fatality rates in the second quarter (Q2), indicating a complex, state-specific interplay of factors such as weather, road types, and economic activities that drive seasonal variations in accident frequency and severity.

Statistical Differences in Accident Metrics

The two-factor ANOVA revealed significant main effects for both state ($F=336.225$, $p<0.001$) and crash metrics ($F=654.845$, $p<0.001$), explaining approximately 90% of the variance in the data ($R^2=0.900$). More importantly, a significant interaction effect between state and crash metric was observed ($F=80.006$, $p<0.001$), indicating that the relationship between geographic state and road traffic accident data depends critically on the specific metric being examined.

Duncan's Multiple Range Test grouped the seven states into five distinct subsets based on their mean reported cases of road traffic accidents ($p<0.05$). Kaduna State formed a unique group by itself with the highest mean accident rate (659.01), followed by Kano (260.42) and Jigawa (229.77) in separate subsets. Katsina (163.73) constituted another distinct group, while Kebbi (116.26), Zamfara (104.45), and Sokoto (85.79) formed the group with the lowest accident rates.

Accident Severity Analysis

The comparative analysis of accident severity revealed critical insights beyond sheer accident volume (Table 3). While Kaduna State bore the overwhelming burden in absolute terms (7,804 crashes resulting in 4,348 deaths and 22,009 injuries), standardized rates showed that states like Katsina and Zamfara had the highest fatality rates (0.64), indicating that each individual crash in these states was more likely to result in death.

Table 4: Comparative Severity and Mortality Rates of Road Traffic Accidents by State (2016-2024)

State	Total RTC	Total NK	Total NI	Total PI	Fatality Rate (NK/RTC)	CSI ((NI+NK)/PI)
Jigawa	2130	1036	5917	12842	0.49	0.54
Kaduna	7804	4348	22009	44392	0.56	0.59
Kano	3134	1759	8288	15812	0.56	0.64

State	Total RTC	Total NK	Total NI	Total PI	Fatality Rate (NK/RTC)	CSI ((NI+NK)/PI)
Katsina	1750	1127	5678	10387	0.64	0.66
Kebbi	1473	728	1473	7804	0.49	0.59
Sokoto	1030	637	3287	5804	0.62	0.68
Zamfara	1099	699	4228	7804	0.64	0.63

The Casualty Severity Index (CSI) was alarmingly high across the entire region, exceeding 50% in every state. Sokoto State had the most severe outcome (0.68), indicating that nearly 7 out of every 10 people involved in a crash became a casualty (either injured or killed). This suggests widespread systemic issues such as prevalent use of unsafe vehicles, overloading, lack of safety equipment, or high-energy collisions affecting multiple people per incident.

Discussion

This study reveals an escalating road safety crisis in North-West Nigeria, characterized by a dramatic surge in accidents in 2024 and significant variations in both volume and severity across states. The unprecedented increase in road traffic crashes in 2024 warrants particular concern, with accident rates in some states multiplying several times over previous years. This alarming trend may be attributed to multiple factors, including deteriorating security situations that have altered driving patterns, potentially leading to riskier behaviors such as speeding through insecure areas, as well as possible economic factors influencing vehicle maintenance and driver behavior.

The significant interaction effect between state and crash metric underscores the necessity for state-specific interventions rather than a uniform regional approach. While Kaduna requires comprehensive strategies to reduce the overwhelming frequency of accidents, states like Katsina and Zamfara need targeted measures to address the higher deadliness of each crash, potentially through improved emergency response systems and trauma care. This finding aligns with the WHO's emphasis on context-specific solutions in road safety planning. The high casualty severity index across all states, particularly in Sokoto (68%), suggests fundamental issues with vehicle safety standards and road user behavior. This indicates that systemic problems such as overloading, poor vehicle maintenance, and lack of safety equipment (seatbelts, helmets) are widespread across the region. These findings corroborate previous studies identifying human factors and vehicular conditions as primary contributors to accident severity in Nigeria.

CONCLUSION

This study provides compelling evidence of a severe and escalating road traffic accident crisis in North-West Nigeria, characterized by a dramatic surge in accidents in 2024 and substantial variations in both volume and severity across states. The findings confirm that the road safety challenge in the region is not monolithic but comprises distinct state-specific profiles, with Kaduna bearing the highest burden in absolute terms, while Katsina and Zamfara experience the deadliest crashes, and Sokoto has the highest probability of injury or death for those involved.

The complex interaction between geographic factors and accident metrics underscores the limitation of one-size-fits-all approaches to road safety in the region. Instead, effective intervention requires nuanced, evidence-based strategies that address the specific risk profiles of each state. This analysis provides a crucial foundation for policymakers, road safety agencies, and health planners to develop precisely targeted strategies to mitigate this persistent public health emergency.

Based on the findings, we propose the following evidence-based recommendations

i. **State-Tailored Intervention Programs**

Road safety interventions must be specifically customized to the unique accident profile of each state. For Kaduna, the priority should be large-scale, comprehensive measures to reduce the overwhelming frequency of crashes through improved infrastructure, traffic management, and enforcement. In Katsina and Zamfara, the focus must shift to improving trauma care and emergency response to address the higher deadliness of each incident. This approach aligns with the WHO's emphasis on context-specific solutions.

ii. **Enhanced Data Collection Systems**

Implementation of strengthened data collection and reporting protocols by the Federal Road Safety Corps and state agencies to ensure consistency, accuracy, and comprehensiveness. This includes standardizing the capture of critical contextual variables such as causes of accidents, road conditions, and vehicle types, which are essential for deeper causal analysis and effective policy formulation. The integration of new technologies such as Event Data Recorders could enhance data quality

iii. **Targeted Infrastructure and Enforcement Campaigns**

Deployment of evidence-based infrastructure improvements and enforcement campaigns based on identified spatial and temporal patterns. This includes increasing patrols and safety audits during high-risk periods like the first quarter (harmattan season) and at identified accident blackspots, as well as implementing specific measures such as improved signage, road markings, and speed control mechanisms in high-frequency and high-severity corridors. These measures reflect the successful application of black spot analysis in other contexts

iv. **Multi-Agency Public Health and Security Response**

Establishment of a coordinated multi-agency approach to address the underlying factors exacerbating the crisis. This involves integrating road safety into broader public health initiatives, strengthening pre-hospital and emergency medical services to reduce fatality rates, and addressing the security challenges that contribute to risky driving behaviors and accident underreporting in the region. The collaboration models demonstrated in successful road safety coalitions provide valuable templates for such approaches

v. **Advanced Monitoring and Evaluation**

Implementation of robust monitoring and evaluation frameworks to assess the impact of interventions and facilitate continuous improvement. This should include regular statistical analysis of accident data to identify emerging trends, evaluate intervention effectiveness, and refine strategies accordingly. The application of

emerging analytical techniques, including machine learning approaches as demonstrated in previous research, could enhance predictive capabilities and targeted prevention

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