APPLICATION OF MULTIVARIATE ANALYSIS ON THE CASES OF ROAD ACCIDENT BETWEEN GEOPOLITICAL ZONES IN NIGERIA

BY

UTHMON FOLARIN BABATUNDE	**ND/23/STA/PT/OO36**
ABDULYEKEEN WASIU BUKOLA	**ND/23/STA/PT/OO86**
ABDULLAHI AMINAT BUKOLA	**ND/23/STA/FT/OO93**
SAHEED WALIYULAHI AKOREDE	**ND/23/STA/PT/OO41**

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Certification

This is to certify that this project was carried out by **ABDULYEKEEN WASIU BUKOLA** with Matriculation Number **ND/23/STA/FT/OO86.**The project has been read and approved as meeting part of the requirement for the award of Higher National Diploma in Statistics.

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MR. SALAMI O.O Date

Project Supervisor

__________________ __________________

MRS. ELEPO T.A Date

Head of Department

__________________ __________________

External Examiner Date

Dedication

The project is dedicated to almighty Allah and Mr and Mrs Abdulyekeen.

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I would like to express my deepest gratitude to all those who have contributed to the successful completion of this project.

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Abstract

Road traffic accidents are a significant public health concern globally, with developing countries bearing the brunt of the problem. This study investigates the differences in accident cases across Nigeria's six geopolitical zones, aiming to examine the changes in accident cases and compare the determinants of these cases, highlighting regional differences. Data for this study were extracted from the National Bureau of Statistics (NBS), and a MANOVA methodology was employed for analysis. The findings reveal significant differences in road accident cases (fatal, serious, and minor) across the six geopolitical zones in Nigeria. The data indicates distinct patterns of accident occurrences, with fatal accidents showing notable differences between zones such as the North East and South West, and the North West and South South. Serious accidents display significant disparities between the North East and North Central, North East and South West, and other zones, while minor accidents exhibit significant differences particularly involving the North Central and South West, and North West and South West. These findings suggest that the geographical location within Nigeria significantly impacts the frequency and severity of road accidents.

Keywords: *road traffic accidents, public health, geopolitical zones, Nigeria, accident severity, regional differences, MANOVA, National Bureau of Statistics*.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Road traffic accidents are a significant public health concern globally, with developing countries bearing the brunt of the problem. Nigeria, as one of the most populous countries in Africa, faces a severe road safety crisis. Road accidents in Nigeria result in a high number of fatalities and injuries annually, impacting the nation's socio-economic development. This study seeks to explore the background of road accident cases in Nigeria, shedding light on their causes, consequences, and possible preventive measures.

Nigeria's road network has evolved significantly over the decades, influenced by urbanization, economic growth, and increasing vehicle ownership. Despite these developments, road infrastructure and safety regulations have not kept pace, leading to a rise in road accidents. Historically, inadequate road maintenance, poor driving habits, and lax enforcement of traffic laws have contributed to the high incidence of road traffic accidents (Oluwasanmi, 2015).

According to the Federal Road Safety Corps (FRSC), Nigeria records thousands of road accidents annually. In 2019, the National Bureau of Statistics (NBS) reported over 11,000 road accidents, resulting in more than 5,000 deaths and countless injuries (NBS, 2019). These statistics highlight the urgent need for effective road safety interventions.

Several factors contribute to the high rate of road accidents in Nigeria: Many roads in Nigeria are in a state of disrepair, with potholes, lack of signage, and inadequate lighting being common issues. These conditions increase the likelihood of accidents (Adeniji, 2000). Reckless driving, over-speeding, and driving under the influence of alcohol or drugs are prevalent among Nigerian drivers. These behaviors significantly elevate the risk of road traffic accidents (Adejumo, 2018). Many vehicles on Nigerian roads are not roadworthy due to poor maintenance practices. Faulty brakes, worn-out tires, and other mechanical issues often lead to accidents (FRSC, 2020).The enforcement of traffic laws in Nigeria is often inconsistent and inadequate. Corruption and lack of resources hamper the efforts of traffic law enforcement agencies (Olagunju, 2016).There is a lack of effective public education and awareness campaigns about road safety. Many road users are not adequately informed about safe driving practices (Eke, 2017).

The economic impact of road accidents in Nigeria is profound. The cost of medical care for accident victims, loss of productivity, and damage to property amounts to billions of Naira annually. Furthermore, road accidents have significant social consequences, including loss of breadwinners, psychological trauma, and the burden on healthcare systems (Olorunfemi, 2014).The Nigerian government has made efforts to address road safety issues through various policies and the establishment of agencies such as the Federal Road Safety Corps (FRSC). However, the effectiveness of these measures has been limited by factors such as inadequate funding, poor implementation, and lack of coordination among stakeholders (FRSC, 2020).Road accidents are a significant public health issue worldwide, with developing countries like Nigeria experiencing particularly high rates. The frequency and severity of road traffic accidents (RTAs) in Nigeria are alarming, making it a critical area of study. This research aims to explore the underlying causes, impacts, and potential solutions to the problem of road accidents in Nigeria.

Over the past few decades, Nigeria has seen a marked increase in road traffic accidents. The Federal Road Safety Corps (FRSC) reports that road accidents are among the leading causes of death in the country. Historical data indicates a correlation between the increase in vehicular population and the rise in road accidents (FRSC, 2020). The poor state of road infrastructure, coupled with inadequate traffic law enforcement, has exacerbated this issue.

To address the issue of road accidents in Nigeria, several strategies can be implemented: Investing in the construction and maintenance of roads can reduce accident rates. Proper drainage systems, road markings, and signage are essential for safe driving conditions (FRSC, 2020). Enhancing the capacity of traffic enforcement agencies and reducing corruption can improve compliance with traffic regulations. Implementing strict penalties for traffic violations can deter reckless behaviour (Oginni et al., 2007).Establishing comprehensive driver education programs and ensuring rigorous testing for driver's licenses can improve driving skills and awareness of traffic rules (Asogwa, 1992).Regular vehicle inspections and enforcement of maintenance standards can reduce the incidence of mechanical failures on the roads (Eke, 2001).Developing a robust emergency response system, including well-equipped ambulances and trained personnel, can improve the survival rates of accident victims (Nzegwu et al., 2008).

1.2 Statement of the Problem

Road traffic accidents (RTAs) in Nigeria have become a critical public health crisis, characterized by alarming rates of morbidity and mortality. Despite various efforts to curb this menace, the incidence of RTAs continues to rise, driven by factors such as poor road infrastructure, reckless driving behaviors, inadequate vehicle maintenance, and weak enforcement of traffic laws. This persistent problem not only results in significant economic losses due to medical expenses and damage to property but also inflicts severe social and psychological trauma on victims and their families. Addressing the root causes and implementing effective mitigation strategies is essential to reduce the devastating impact of road accidents in Nigeria.

1.3 Aim and Objectives of the study

This study aim at investigating the differences in accident cases across Nigeria's six geopolitical zones while the objectives of the study are :

i. Examine the changes in accident cases across the six geopolitical zones in Nigeria
ii. Compare the determinant of accident cases across the six zones, highlighting regional differences

1.4 Significant of the Study

The significance of this study lies in its potential to provide a comprehensive understanding of the factors influencing road accident rates across different geopolitical zones in Nigeria through the application of multivariate analysis. By identifying and quantifying the impact of various socio-economic, environmental, and infrastructural variables, policymakers can develop targeted interventions to reduce accident rates. This approach enables the formulation of region-specific strategies, improving resource allocation and enhancing the effectiveness of road safety measures. Ultimately, the findings can contribute to a reduction in road traffic fatalities and injuries, fostering safer road environments and promoting sustainable socio-economic development across Nigeria.

1.5 Scope of the Study

This study focuses on applying multivariate analysis to examine road accident cases across Nigeria's six geopolitical zones, categorizing them into minor, serious, and fatal incidents. The methodology involves utilizing multivariate analysis to explore the relationships between various contributing factors such as road conditions, driver behavior, vehicle maintenance, and enforcement of traffic laws. The data, extracted from the National Bureau of Statistics (NBS), provides a comprehensive and representative dataset for each zone. Through this analysis, the study aims to identify key determinants and regional disparities in road accident severity, offering insights for targeted interventions and policy recommendations to enhance road safety in Nigeria.

CHAPTER TWO

LITERATURE REVIEW

2.1 Empirical Review of Literature

The empirical literature on road traffic accidents (RTAs) in Nigeria highlights the significant public health and economic burden posed by these incidents. Studies have consistently shown that RTAs are a leading cause of injury and death in the country. For instance, a study by Olukoga (2003) found that road traffic accidents accounted for a significant proportion of emergency room visits and hospital admissions, with considerable variations across different regions of Nigeria. Similarly, Nzegwu et al. (2008) reported that RTAs were a leading cause of mortality in urban areas, particularly among young adults and working-age individuals.

Further empirical studies underscore the varied impact of socio-economic and environmental factors on road traffic accidents (RTAs) across Nigeria's geopolitical zones. Research by Arosanyin et al. (2011) highlighted the significant role of urbanization and economic activities in influencing the frequency and severity of RTAs. Their study found that zones with higher urbanization rates, such as the South-West, reported more frequent and severe accidents compared to less urbanized zones like the North-East.

Moreover, the influence of climatic conditions on RTAs has also been examined. Studies indicate that weather conditions, such as heavy rainfall in the rainy season, significantly contribute to the occurrence of accidents due to poor visibility and slippery roads (Faduyile et al., 2017). This factor varies regionally, with the southern zones experiencing more frequent and intense rainfall, thus leading to a higher incidence of weather-related accidents.

In terms of human factors, Al-Reesi et al. (2013) utilized multivariate analysis to explore the impact of driver demographics on RTA outcomes. Their findings revealed that younger drivers and commercial vehicle operators are more prone to involve in severe accidents. This pattern is consistent across Nigeria's geopolitical zones, reflecting broader trends observed in road safety research globally.

The utilization of Geographic Information Systems (GIS) has also enhanced the analysis of spatial patterns in RTAs. For example, a study by Oyeyemi and Adebayo (2012) applied GIS tools to map accident hotspots in the South-West zone, revealing significant clustering of accidents in urban centers like Lagos and Ibadan. Such spatial analysis facilitates targeted interventions in high-risk areas.

A key factor in understanding the distribution and determinants of RTAs in Nigeria is the role of regional disparities. Research has shown that the incidence and severity of road accidents vary widely between the six geopolitical zones of Nigeria. According to Eke (2001), the South-East and South-South zones, which have some of the country's busiest road networks, also report higher rates of accidents compared to the relatively less trafficked Northern zones.

Empirical studies utilizing multivariate analysis have provided deeper insights into the complex interplay of factors contributing to RTAs. For instance, Onyemaechi et al. (2019) employed multivariate logistic regression to analyze the influence of driver behavior, vehicle condition, road quality, and enforcement of traffic laws on accident severity. Their findings underscored the significant impact of poor road conditions and inadequate vehicle maintenance on the likelihood of serious and fatal accidents.

The National Bureau of Statistics (NBS) provides extensive data that have been used in various empirical studies to analyze trends and patterns in road traffic accidents. These studies often employ advanced statistical techniques, including multivariate analysis, to control for confounding variables and isolate the effects of specific risk factors. For example, Adeloye et al. (2016) used data from the NBS to conduct a multivariate analysis of road traffic injuries and fatalities, identifying key demographic and environmental predictors of accident severity.

2.2 Theoretical Literature Review

The theoretical framework for studying road traffic accidents encompasses several models and theories from public health, transportation engineering, and social sciences. One prominent theoretical approach is the Haddon Matrix, developed by William Haddon in the 1970s, which provides a comprehensive framework for understanding the multifaceted nature of traffic accidents. The Haddon Matrix considers factors related to the human (driver behavior, skills), vehicle (safety features, maintenance), and environment (road conditions, weather) in the pre-crash, crash, and post-crash phases (Haddon, 1972).

Another relevant theoretical model is the Systems Theory, which views road traffic as a complex system comprising interdependent components, including drivers, vehicles, infrastructure, and regulatory frameworks. This approach emphasizes the need for a holistic understanding of how these components interact to influence the occurrence and outcomes of road traffic accidents (Reason, 1990). The Systems Theory underscores the importance of a multidisciplinary approach to road safety, integrating insights from engineering, psychology, and public policy.

The Theory of Planned Behavior (TPB), developed by Ajzen (1991), is also frequently applied in understanding driver behavior, a critical determinant of road traffic accidents. The TPB posits that individual behavior is driven by behavioral intentions, which are influenced by attitudes towards the behavior, subjective norms, and perceived behavioral control. Studies applying TPB in the context of road safety have shown that interventions targeting driver attitudes and perceptions can effectively reduce risky driving behaviors and, consequently, the incidence of accidents (Parker et al., 1995).

Additionally, the Risk Homeostasis Theory (RHT), proposed by Wilde (1982), suggests that individuals adjust their behavior in response to the perceived level of risk. In the context of road safety, this theory implies that drivers may compensate for improved vehicle safety features or better road conditions by engaging in riskier driving behaviors, thereby maintaining a constant level of perceived risk. This theory has been used to explain the limited effectiveness of some safety interventions and highlights the need for comprehensive strategies that address both technical and behavioral aspects of road safety.

Behavioral adaptation is further elaborated in the concept of Safety Culture, which posits that the attitudes, beliefs, perceptions, and values shared by members of a community significantly influence their behavior regarding road safety (Guldenmund, 2000). In Nigeria, regional differences in safety culture can contribute to the variability in RTA rates across geopolitical zones. Understanding these cultural factors is crucial for developing tailored road safety campaigns.

The Ecological Model of Road Safety emphasizes the interaction between individuals and their physical and social environments (Christoffel & Gallagher, 2006). This model suggests that effective road safety interventions must consider factors at multiple levels, including individual behavior, community norms, and policy regulations. Applying this model to Nigeria, interventions might need to address diverse environmental contexts, from the congested urban roads of Lagos to the rural highways of the North-West.

Additionally, the Theory of Human Error, particularly the Swiss Cheese Model developed by Reason (1990), provides a framework for understanding how multiple layers of defense failures can lead to accidents. This model is particularly relevant for analyzing road traffic systems, where accidents often result from a combination of driver errors, vehicle defects, and infrastructural inadequacies. By identifying and addressing these latent failures, policymakers can enhance overall road safety.

Lastly, the concept of Vision Zero, originating from Sweden, advocates for a systemic approach to road safety that prioritizes human life and health over all other considerations (Tingvall & Haworth, 1999). Vision Zero's principles can be adapted to the Nigerian context to develop a comprehensive strategy aimed at eliminating road fatalities and serious injuries. This approach requires a paradigm shift towards designing forgiving road systems that accommodate human errors without resulting in severe consequences.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter discuss the details relating to where the data is collected, how the data is collected, source of the data collected as well as the method of analysis to be used in performing the analysis of this project work. The method of analysis MANOVA (Multivariate analysis of variance) is employed

3.1.2 Sources of data collection

There are two major sources

i. Primary data

ii. Secondary data

The data used for this study is secondary data obtained from National Bureau of Statistics (NBS) website. In addition, some other forms of information used in this project were obtained from journals.

3.1.3 Methods of Data Collection

Data are basic raw materials for any statistic investigation. In any statistical research, there are various methods of obtaining data whose source can be primary or secondary. In this project, the secondary data is being employed to guarantee the reliability and the adequacy of the required data.

3.2 Multivariate Analysis of Variance (MANOVA)

Multivariate analysis of variance (MANOVA) generalizes ANOVA to allow multivariate responses. For the MANOVA set up, we have observation vectors y_{ij} from sample i = 1, . . . k, with j = 1, . . . , n indexing the observation. Each observation vector yij is a p-dimensional multivariate normal vector with mean vector μi and common covariance matrix Σ. The set up can be written in a way analgous to balanced one-way ANOVA with individual observations replaced with observation vectors.

	Sample 1 from $N_p(\boldsymbol{\mu}_1, \boldsymbol{\Sigma})$	Sample 2 from $N_p(\boldsymbol{\mu}_2, \boldsymbol{\Sigma})$	. . .	Sample k from $N_p(\boldsymbol{\mu}_k, \boldsymbol{\Sigma})$
	$\mathbf{y}_{11}$	$\mathbf{y}_{21}$	. . .	$\mathbf{y}_{k1}$
	$\mathbf{y}_{12}$	$\mathbf{y}_{22}$	. . .	$\mathbf{y}_{k2}$
	⋮	⋮		⋮
	$\mathbf{y}_{1n}$	$\mathbf{y}_{2n}$	. . .	$\mathbf{y}_{kn}$
Total	$\mathbf{y}_{1.}$	$\mathbf{y}_{2.}$	. . .	$\mathbf{y}_{k.}$
Mean	$\overline{\mathbf{y}}_{1.}$	$\overline{\mathbf{y}}_{2.}$	. . .	$\overline{\mathbf{y}}_{k.}$

Totals and means are defined as follows:

Total of the ith sample: $\mathbf{y}_{i.} = \sum_{j=1}^{n} \mathbf{y}_{ij}$.

Overall total: $\mathbf{y}_{..} = \sum_{i=1}^{k} \sum_{j=1}^{n} \mathbf{y}_{ij}$.

Mean of the ith sample: $\overline{\mathbf{y}}_{i.} = \mathbf{y}_{i.}/n$.

Overall mean: $\overline{\mathbf{y}}_{..} = \mathbf{y}_{..}/kn$.

The model can be written as

$$\mathbf{y_{ij} = \mu + \alpha_i + \varepsilon_{ij} = \mu i + \varepsilon_{ij}}$$

where we assume

$$\mathbf{y_{ij} \sim Np(\mu_i, \Sigma)}$$

For r = 1, . . . , p, we can also write the model as

$$\begin{pmatrix} y_{ij1} \\ y_{ij2} \\ \vdots \\ y_{ijr} \end{pmatrix} = \begin{pmatrix} \mu_{i1} \\ \mu_{i2} \\ \vdots \\ \mu_{ir} \end{pmatrix} + \begin{pmatrix} \varepsilon_{ij1} \\ \varepsilon_{ij2} \\ \vdots \\ \varepsilon_{ijr} \end{pmatrix}$$

so that for each variable $r = 1, \ldots, p$, the model is

$$\mathbf{y_{ijr} = \mu_{ir} + \varepsilon_{ijr}}$$

The null and alternative hypotheses are

$$\mathbf{H_0 : \mu_1 = \cdot \cdot \cdot = \mu_k ,}$$

$$\mathbf{H_1 : \mu_i \neq \mu_j} \text{ for at least one pair } \mathbf{i \neq j}$$

i.e., that each population has the same mean vector and that that at least two populations have different mean vectors, or that at least two populations have at least one variable with different means.

The null hypothesis can be written also as p sets of $k - 1$ equalities:

$$\begin{array}{l} \mu 11 = \mu 21 = \cdot \cdot \cdot = \mu k1 \\ \mu 12 = \mu 22 = \cdot \cdot \cdot = \mu k2 \\ . \qquad\qquad . \\ . \qquad\qquad . \\ . \qquad\qquad . \\ = \quad = \quad = \\ \mu 1p = \mu 1p = \cdot \cdot \cdot = \mu kp \end{array}$$

This is a total of $p(k - 1)$ equalities, and any one of these failing is sufficient to make H_0 false.

Analogous to the SSH (Sums of squares hypothesis) and SSE (sums of squares for error), we have

$$\mathbf{H} = n\sum_{i=1}^{k}(\bar{\mathbf{y}}_{i.} - \bar{\mathbf{y}}_{..})(\bar{\mathbf{y}}_{i.} - \bar{\mathbf{y}}_{..})' = \sum_{i=1}^{k}\frac{1}{n}\mathbf{y}_{i.}\mathbf{y}_{i.}' - \frac{1}{kn}\mathbf{y}_{..}\mathbf{y}_{..}'$$

$$\mathbf{E} = \sum_{i=1}^{k}\sum_{j=1}^{n}(\mathbf{y}_{ij} - \bar{\mathbf{y}}_{i.})(\mathbf{y}_{ij} - \bar{\mathbf{y}}_{i.})' = \sum_{ij}\mathbf{y}_{ij}\mathbf{y}_{ij}' - \frac{1}{n}\sum_{i}\mathbf{y}_{i.}\mathbf{y}_{i.}'$$

The **E** and **H** matrices are both $p \times p$, but not necessarily full rank. The rank of H is $\min(p, v_H)$, where v_H is the degrees of freedom associated with the hypothesis, i.e. $k - 1$.

We can think the pooled covariance matrix as

$$Spl = E / (n - 1)K$$

With

$$E(Spl) = \Sigma$$

However, if the sample mean vectors were equal for each population, then we would have $H = 0$.

Thus **H** has the form

$$\mathbf{H} = \begin{pmatrix} SSH_{11} & SPH_{12} & \cdots & SPH_{1p} \\ SPH_{12} & SSH_{22} & \cdots & SPH_{2p} \\ \vdots & \vdots & & \vdots \\ SPH_{1p} & SPH_{2p} & \cdots & SSH_{pp} \end{pmatrix},$$

here, for example,

$$SSH_{22} = n\sum_{i=1}^{k}(\bar{y}_{i.2} - \bar{y}_{..2})^2 = \sum_{i}\frac{y_{i.2}^2}{n} - \frac{y_{..2}^2}{kn},$$

$$SPH_{12} = n\sum_{i=1}^{k}(\bar{y}_{i.1} - \bar{y}_{..1})(\bar{y}_{i.2} - \bar{y}_{..2}) = \sum_{i}\frac{y_{i.1}y_{i.2}}{n} - \frac{y_{..1}y_{..2}}{kn}.$$

$$\text{SSE}_{22} = \sum_{i=1} \sum_{j=1} (y_{ij2} - \overline{y}_{i.2})^2 = \sum_{ij} y_{ij2}^2 - \sum_{i} \frac{y_{i.2}}{n},$$

$$\text{SPE}_{12} = \sum_{i=1}^{k} \sum_{j=1}^{n} (y_{ij1} - \overline{y}_{i.1})(y_{ij2} - \overline{y}_{i.2}) = \sum_{ij} y_{ij1} y_{ij2} - \sum_{i} \frac{y_{i.1} y_{i.2}}{n}$$

The **E** and **H** matrices can be used in different ways to test the null hypothesis. Wilks' Test Statistic is

$$\Lambda = \frac{|\text{E}|}{|\text{E} + \text{H}|}$$

The null is rejected if $\Lambda < \Lambda_{\alpha,p,vH\ ,vE}$ where v_H is the degrees of freedom for the hypothesis, k − 1, and vE is degrees of freedom for error, k(n − 1. The test statistic can instead be converted to an F, but there are different cases.

Parameters p, ν_H	Statistic Having F-Distribution	Degrees of Freedom
Any $p, \nu_H = 1$	$\frac{1 - \Lambda}{\Lambda} \frac{\nu_E - p + 1}{p}$	$p, \nu_E - p + 1$
Any $p, \nu_H = 2$	$\frac{1 - \sqrt{\Lambda}}{\sqrt{\Lambda}} \frac{\nu_E - p + 1}{p}$	$2p, 2(\nu_E - p + 1)$
$p = 1$, any ν_H	$\frac{1 - \Lambda}{\Lambda} \frac{\nu_E}{\nu_H}$	ν_H, ν_E
$p = 2$, any ν_H	$\frac{1 - \sqrt{\Lambda}}{\sqrt{\Lambda}} \frac{\nu_E - 1}{\nu_H}$	$2\nu_H, 2(\nu_E - 1)$

Properties of Wilks' Λ

- We need vE = (n − 1)k ≥ p for the determinants to be positive
- The degrees of freedom for error and hypothesis are the same as for univariate ANOVA

- The distribution of $\Lambda_{p,vH,vE}$ is the same as $\Lambda_{p,vE,vH}$. This saves some space for the table of critical values. I Wilks' Λ can be written as

$$\Lambda = \prod_{i=1}^{\min(p,\nu_H)} \frac{1}{1+\lambda_i}$$

Where λ_i is the ith eigenvalue of $\mathbf{E}^{-1}\mathbf{H}$. Here s = min(p, vH) is the rank of s, which is also the number of nonzero eigenvalues of $E^{-1}H$.

- Λ is in the interval [0,1]. If the sample mean vectors were all equal (for example, if they were all equal to their expected values under the null), then H = 0.
- Increasing the number of variables p decreases the critical value for Λ needed to reject the null hypothesis. This means that it is more difficult to reject H0 (since we reject for small Λ) unless the null hypothesis is false for the new variables. I.e., adding new variables for which the populations are equal makes it harder to reject the null hypothesis.
- When vH = 1, 2 or p = 1, 2, Wilks' Λ is equivalent to an F statistic. Otherwise, an approximate transformation to an F can be used:

$$F = \frac{1-\Lambda^{1/t}}{\Lambda^{1/t}} \frac{\mathrm{df}_2}{\mathrm{df}_1},$$

with df_1 and df_2 degrees of freedom, where

$$df_1 = p\nu_H, \qquad df_2 = wt - \frac{1}{2}(p\nu_H - 2),$$
$$w = \nu_E + \nu_H - \frac{1}{2}(p + \nu_H + 1), \qquad t = \sqrt{\frac{p^2\nu_H^2 - 4}{p^2 + \nu_H^2 - 5}}.$$

If the null hypothesis is rejected, then follow up tests could be made. Fixing r ∈ {1, . . . , p}, one could test.

$$H_{0r} : \mu_{1r} = \mu_{2r} = \cdots = \mu_{kr}$$

which would be a univariate ANOVA test to see if the k populations differ on variable r.

As usual, testing all variables simultaneously and then testing individual variables has better type I error than just testing all variables separately to begin with. It is also possible that the simultaneous test rejects H_0 but that each H0r for r = 1, . . . , p fails to be rejected.

3.2.2 Two-way MANOVA

MANOVA is analogous to ANOVA, with the model being

$$y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_{ij} + \varepsilon_{ijk} = \mu_{ij} + \varepsilon_{ijk}$$

where, for example α_i is a p-dimension vector which is the effect of ith treatment on each of the p variables. All vectors in the model are p-dimensional.

Again we have $\boldsymbol{\alpha i = \mu i. - \mu..}$

The total sum of squares can be partitioned as

$$\mathbf{T} = \mathbf{H_A} + \mathbf{H_B} + \mathbf{H}_{AB} + E$$

Source	Sum of Squares and Products Matrix	df
A	$\mathbf{H}_A = nb \sum_i (\overline{\mathbf{y}}_{i..} - \overline{\mathbf{y}}_{...})(\overline{\mathbf{y}}_{i..} - \overline{\mathbf{y}}_{...})'$	$a-1$
B	$\mathbf{H}_B = na \sum_j (\overline{\mathbf{y}}_{.j.} - \overline{\mathbf{y}}_{...})(\overline{\mathbf{y}}_{.j.} - \overline{\mathbf{y}}_{...})'$	$b-1$
AB	$\mathbf{H}_{AB} = n \sum_{ij} (\overline{\mathbf{y}}_{ij.} - \overline{\mathbf{y}}_{i..} - \overline{\mathbf{y}}_{.j.} + \overline{\mathbf{y}}_{...}) \times (\overline{\mathbf{y}}_{ij.} - \overline{\mathbf{y}}_{i..} - \overline{\mathbf{y}}_{.j.} + \overline{\mathbf{y}}_{...})'$	$(a-1)(b-1)$
Error	$\mathbf{E} = \sum_{ijk} (\mathbf{y}_{ijk} - \overline{\mathbf{y}}_{ij.})(\mathbf{y}_{ijk} - \overline{\mathbf{y}}_{ij.})'$	$ab(n-1)$
Total	$\mathbf{T} = \sum_{ijk} (\mathbf{y}_{ijk} - \overline{\mathbf{y}}_{...})(\mathbf{y}_{ijk} - \overline{\mathbf{y}}_{...})'$	$abn-1$

Tests can be based on Wilks' Λ using

$$\Lambda_A = \frac{|\mathbf{E}|}{|\mathbf{E} + \mathbf{H}_A|} \sim \Lambda_{p,a-1,ab(n-1)}$$

$$\Lambda_B = \frac{|\mathbf{E}|}{|\mathbf{E} + \mathbf{H}_B|} \sim \Lambda_{p,b-1,ab(n-1)}$$

$$\Lambda_{AB} = \frac{|\mathbf{E}|}{|\mathbf{E} + \mathbf{H}_{AB}|} \sim \Lambda_{p,(a-1)(b-1),ab(n-1)}$$

Or you can use eigenvalues of $\mathbf{E}^{-1}\mathbf{H}_A$, $\mathbf{E}^{-1}\mathbf{H}_B$, $\mathbf{E}^{-1}\mathbf{H}_{AB}$

CHAPTER FOUR

DATA PRESENTAION AND ANALYSIS

4.1 Introduction

In this chapter, the study presented the data and the analysis of data. The study analysed the data on accident cases in the six geopolitical zones in Nigeria adopting Multivariate analysis of variance (MANOVA).

4.2 Data Presentation

The data in table 4.1 are the data on the cases of accident collected across the geopolitical zones in Nigeria which was extracted from the National bureau of statistics

Table 4.1: Presentation of Data

Q1 2023				
STATE	**FATAL**	**SERIOUS**	**MINOR**	**TOTAL CASUALTY**
Abia	7	5	0	61
Adamawa	13	40	0	172
Akwa Ibom	3	6	0	19
Anambra	4	8	3	79
Bauchi	43	56	11	612
Bayelsa	2	2	2	12
Benue	3	27	7	88
Borno	6	17	3	85
Cross River	5	7	0	42
Delta	12	7	3	121

Ebonyi	9	30	10	145
Edo	14	37	4	224
Ekiti	1	14	7	50
Enugu	10	23	4	120
FCT	71	245	66	767
Gombe	12	48	1	266
Imo	9	8	1	69
Jigawa	23	105	1	426
Kaduna	65	129	9	921
Kano	23	39	4	378
Katsina	13	10	0	172
Kebbi	9	18	0	190
Kogi	30	61	6	377
Kwara	28	60	3	382
Lagos	18	60	35	270
Nasarawa	18	118	7	338
Niger	34	83	6	501
Ogun	60	175	34	820
Ondo	23	71	5	282
Osun	10	54	5	268
Oyo	32	69	5	300
Plateau	23	70	7	475
Rivers	5	8	5	46
Sokoto	9	9	0	109
Taraba	8	47	0	225
Yobe	14	23	1	241
Zamfara	8	12	0	127
TOTAL	**677**	**1801**	**255**	**9780**

Q2 2023

STATE	FATAL	SERIOUS	MINOR	TOTAL CASUALTY
Abia	3	6	3	25
Adamawa	5	51	1	180
Akwa Ibom	5	10	2	38
Anambra	10	11	13	72
Bauchi	33	66	1	483
Bayelsa	2	5	0	38
Benue	19	38	0	185
Borno	9	43	2	177
Cross River	9	15	3	107
Delta	9	13	6	101
Ebonyi	15	29	4	140
Edo	27	28	16	272
Ekiti	6	17	5	60
Enugu	13	25	6	169
FCT	52	214	54	718
Gombe	17	42	1	250
Imo	6	11	3	45
Jigawa	29	77	1	344
Kaduna	61	117	12	874
Kano	22	60	5	318
Katsina	17	20	0	165
Kebbi	10	25	2	113
Kogi	31	68	8	417
Kwara	18	55	4	325
Lagos	35	58	45	261
Nasarawa	31	167	10	587
Niger	39	107	4	577
Ogun	67	172	44	718
Ondo	29	76	8	317
Osun	18	58	13	284
Oyo	55	83	6	464
Plateau	11	46	4	227
Rivers	8	10	4	45
Sokoto	6	11	0	66
Taraba	8	38	1	109

Yobe	16	33	1	337
Zamfara	5	14	0	178
TOTAL	**756**	**1919**	**292**	**9786**

Q3 2023

STATE	FATAL	SERIOUS	MINOR	TOTAL CASUALTY
Abia	2	8	5	53
Adamawa	5	26	1	95
Akwa Ibom	2	6	0	17
Anambra	10	18	6	109
Bauchi	13	35	3	175
Bayelsa	0	2	3	2
Benue	10	45	0	189
Borno	9	19	0	110
Cross River	3	11	4	37
Delta	15	11	4	78
Ebonyi	7	12	0	49
Edo	10	20	3	95
Ekiti	10	15	4	76
Enugu	13	16	3	127
FCT	63	216	70	689
Gombe	7	29	4	151
Imo	7	10	3	117
Jigawa	12	52	0	238
Kaduna	42	71	4	563
Kano	15	27	1	156
Katsina	6	12	0	91
Kebbi	0	10	0	14

Kogi	27	58	11	407
Kwara	23	43	7	273
Lagos	18	64	24	198
Nasarawa	23	128	11	448
Niger	27	69	5	438
Ogun	51	133	28	666
Ondo	26	38	4	205
Osun	20	36	11	280
Oyo	36	74	8	377
Plateau	4	35	5	104
Rivers	2	9	2	52
Sokoto	5	9	1	47
Taraba	0	24	0	79
Yobe	8	19	1	105
Zamfara	1	9	0	39
TOTAL	**532**	**1419**	**236**	**6949**

Source : This data was obtained from the National Bureau of Statistics website

4.3 DATA ANALYSIS

4.3.1 Multivariate Test

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.704	16.049[b]	4.000	27.000	.000
	Wilks' Lambda	.296	16.049[b]	4.000	27.000	.000
	Hotelling's Trace	2.378	16.049[b]	4.000	27.000	.000
	Roy's Largest Root	2.378	16.049[b]	4.000	27.000	.000
GZ	Pillai's Trace	1.152	2.428	20.000	120.000	.002
	Wilks' Lambda	**.188**	**2.965**	**20.000**	**90.499**	**.000**
	Hotelling's Trace	2.625	3.347	20.000	102.000	.000
	Roy's Largest Root	1.766	10.596[c]	5.000	30.000	.000

The Multivariate Tests shows that there is significant difference in the mean accident cases across the six-geopolitical zones with the P-value (<0.0001), wilks lambda value (0.188), F=2.965 in which the P-value is less than the level of significant 0.05 which implies that the average road accident cases across the six-geopolitical zones are differ

4.3.2 Test between Subject effects

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Fatal	2151.225[a]	5	430.245	4.165	.005
	Serious	15788.615[b]	5	3157.723	5.101	.002
	Minor	656.148[c]	5	131.230	5.682	.001
Intercept	Fatal	5772.528	1	5772.528	55.880	.000
	Serious	38563.774	1	38563.774	62.297	.000
	Minor	748.597	1	748.597	32.415	.000
Geopolitical zones	Fatal	2151.225	5	430.245	4.165	.005
	Serious	15788.615	5	3157.723	5.101	.002
	Minor	656.148	5	131.230	5.682	.001
Error	Fatal	3099.081	30	103.303		
	Serious	18571.024	30	619.034		
	Minor	692.824	30	23.094		
Total	Fatal	11205.000	36			
	Serious	74293.000	36			
	Minor	2087.000	36			
Corrected Total	Fatal	5250.306	35			
	Serious	34359.639	35			
	Minor	1348.972	35			

Above shows that there is significant difference in the accident case (fatal) across the six geopolitical zones in Nigeria with the (F value=4.165 , df = 5 and the P-value 0.005) which is less than the level of significant 0.05 also, there is significant difference in the accident case (serious) with the (F value=5.101, df = 5 and P-value 0.002) which is less than the level of significant and there is significant difference in the accident case (minor) across the geopolitical zones in Nigeria with the (F value 5.682, df=5 and the P-value 0.11) which is also less than 0.05

4.3.4 Multiple Comparisons

Multiple Comparisons

LSD

Dependent Variable	*(I) Geopolitical _zones*	*(J) Geopolitical _zones*	*Mean Difference (I-J)*	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Fatal	*North East*	*North West*	*-4.57*	5.655	.425	-16.12	6.98
		North Central	*-12.00**	5.868	.050	-23.98	-.02
		South East	.40	6.154	.949	-12.17	12.97
		South South	1.67	5.868	.778	-10.32	13.65
		South West	-19.83*	5.868	.002	-31.82	-7.85
	North West	North East	4.57	5.655	.425	-6.98	16.12
		North Central	-7.43	5.655	.199	-18.98	4.12
		South East	4.97	5.951	.410	-7.18	17.13
		South South	6.24	5.655	.279	-5.31	17.79
		South West	-15.26*	5.655	.011	-26.81	-3.71
	North Central	North East	12.00*	5.868	.050	.02	23.98
		North West	7.43	5.655	.199	-4.12	18.98
		South East	12.40	6.154	.053	-.17	24.97
		South South	13.67*	5.868	.027	1.68	25.65

		South West	-7.83	5.868	.192	-19.82	4.15
	South East	North East	-.40	6.154	.949	-12.97	12.17
		North West	-4.97	5.951	.410	-17.13	7.18
		North Central	-12.40	6.154	.053	-24.97	.17
		South South	1.27	6.154	.838	-11.30	13.84
		South West	-20.23*	6.154	.003	-32.80	-7.66
	South South	North East	-1.67	5.868	.778	-13.65	10.32
		North West	-6.24	5.655	.279	-17.79	5.31
		North Central	-13.67*	5.868	.027	-25.65	-1.68
		South East	-1.27	6.154	.838	-13.84	11.30
		South West	-21.50*	5.868	.001	-33.48	-9.52
	South West	North East	19.83*	5.868	.002	7.85	31.82
		North West	15.26*	5.655	.011	3.71	26.81
		North Central	7.83	5.868	.192	-4.15	19.82
		South East	20.23*	6.154	.003	7.66	32.80
		South South	21.50*	5.868	.001	9.52	33.48
Serious	North East	North West	-1.81	13.842	.897	-30.08	26.46
		North Central	-37.67*	14.365	.014	-67.00	-8.33
		South East	13.33	15.066	.383	-17.44	44.10
		South South	15.50	14.365	.289	-13.84	44.84
		South West	-34.67*	14.365	.022	-64.00	-5.33
	North West	North East	1.81	13.842	.897	-26.46	30.08
		North Central	-35.86*	13.842	.015	-64.13	-7.59
		South East	15.14	14.568	.307	-14.61	44.90
		South South	17.31	13.842	.221	-10.96	45.58
		South West	-32.86*	13.842	.024	-61.13	-4.59
	North Central	North East	37.67*	14.365	.014	8.33	67.00
		North West	35.86*	13.842	.015	7.59	64.13
		South East	51.00*	15.066	.002	20.23	81.77

		South South	53.17*	14.365	.001	23.83	82.50
		South West	3.00	14.365	.836	-26.34	32.34
	South East	North East	-13.33	15.066	.383	-44.10	17.44
		North West	-15.14	14.568	.307	-44.90	14.61
		North Central	-51.00*	15.066	.002	-81.77	-20.23
		South South	2.17	15.066	.887	-28.60	32.94
		South West	-48.00*	15.066	.003	-78.77	-17.23
	South South	North East	-15.50	14.365	.289	-44.84	13.84
		North West	-17.31	13.842	.221	-45.58	10.96
		North Central	-53.17*	14.365	.001	-82.50	-23.83
		South East	-2.17	15.066	.887	-32.94	28.60
		South West	-50.17*	14.365	.002	-79.50	-20.83
	South West	North East	34.67*	14.365	.022	5.33	64.00
		North West	32.86*	13.842	.024	4.59	61.13
		North Central	-3.00	14.365	.836	-32.34	26.34
		South East	48.00*	15.066	.003	17.23	78.77
		South South	50.17*	14.365	.002	20.83	79.50
Minor	North East	North West	.64	2.674	.812	-4.82	6.10
		North Central	-5.00	2.775	.082	-10.67	.67
		South East	-1.30	2.910	.658	-7.24	4.64
		South South	-1.17	2.775	.677	-6.83	4.50
		South West	-11.67*	2.775	.000	-17.33	-6.00
	North West	North East	-.64	2.674	.812	-6.10	4.82
		North Central	-5.64*	2.674	.043	-11.10	-.18
		South East	-1.94	2.814	.495	-7.69	3.80
		South South	-1.81	2.674	.504	-7.27	3.65
		South West	-12.31*	2.674	.000	-17.77	-6.85
	North Central	North East	5.00	2.775	.082	-.67	10.67
		North West	5.64*	2.674	.043	.18	11.10

	South East	3.70	2.910	.213	-2.24	9.64
	South South	3.83	2.775	.177	-1.83	9.50
	South West	-6.67*	2.775	.023	-12.33	-1.00
South East	North East	1.30	2.910	.658	-4.64	7.24
	North West	1.94	2.814	.495	-3.80	7.69
	North Central	-3.70	2.910	.213	-9.64	2.24
	South South	.13	2.910	.964	-5.81	6.08
	South West	-10.37*	2.910	.001	-16.31	-4.42
South South	North East	1.17	2.775	.677	-4.50	6.83
	North West	1.81	2.674	.504	-3.65	7.27
	North Central	-3.83	2.775	.177	-9.50	1.83
	South East	-.13	2.910	.964	-6.08	5.81
	South West	-10.50*	2.775	.001	-16.17	-4.83
South West	North East	11.67*	2.775	.000	6.00	17.33
	North West	12.31*	2.674	.000	6.85	17.77
	North Central	6.67*	2.775	.023	1.00	12.33
	South East	10.37*	2.910	.001	4.42	16.31
	South South	10.50*	2.775	.001	4.83	16.17

From the multiple comparison result, it shows that there is significant relation in the road accident case fatal between North East and South West (0.002), North West and South South (0.011), North Central and South South South (0.027) also there is significant difference in the road accident case (serious) between North East and North Central (0.014), North East and South West (0.022), North West and North

Central (0.015), North West and South West (0.024), south East and North Central (0.002), North Central and South (0.001), South East and South West (0.003) and for minor road accident case, there is significant difference between North Central and South West (< 0.001), North West & North Central (0.043), North West & South West (0.001), North Central & North East (0.082), North Central & South West (0.023), South East & South West (0.001), South South & South West (0.001) with the P-value less than the level of significant.

CHAPTER FIVE

SUMMARY OF FINDINGS AND CONCLUSION

5.1 Summary of Findings

The test between the subject shows that there is significant difference in the accident case (fatal) across the six geopolitical zones in Nigeria with the (F value=4.165 , df = 5 and the P-value 0.005) which is less than the level of significant 0.05 also, there is significant difference in the accident case (serious) with the (F value=5.101, df = 5 and P-value 0.002) which is less than the level of significant and there is significant difference in the accident case (minor) across the geopolitical zones in Nigeria with the (F value 5.682, df=5 and the P-value 0.01) which is also less than 0.05

From the multiple comparison result, it shows that there is significant relation in the road accident case fatal between North East and South West (0.002), North West and South South (0.011), North Central and South South South (0.027) also there is significant difference in the road accident case (serious) between North East and North Central (0.014), North East and South West (0.022), North West and North Central (0.015), North West and South West (0.024), south East and North Central (0.002), North Central and South (0.001), South East and South West (0.003) and for minor road accident case, there is significant difference between North Central and South West (< 0.001), North West & North Central (0.043), North West & South West (0.001), North Central & North East (0.082), North Central & South West (0.023), South East & South West (0.001), South South & South West (0.001) with the P-value less than the level of significant.

5.2 Conclusion

The findings reveal significant differences in road accident cases (fatal, serious, and minor) across the six geopolitical zones in Nigeria. The data indicates distinct patterns of accident occurrences, with fatal accidents showing notable differences between zones such as the North East and South West, and the North West and South South. Serious accidents display significant disparities between the North East and North Central, North East and South West, and other zones, while minor accidents exhibit significant differences particularly involving the North Central and South West, and North West and South West. These findings suggest that the geographical location within Nigeria significantly impacts the frequency and severity of road accidents.

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