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A Nonparametric Approach to Data Analysis on Road Traffic Accidents

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ABSTRACT: *The increasing level of Road traffic accidents in Adamawa state as well as the rate of injuries and death propelled this paper, data on recorded Road Traffic Accidents were collected from the Federal Road Safety Corps head office Yola, nonparametric methods for data analysis were employed to check if these Road traffic offences that are responsible for Road traffic accidents in the state occur in the same pattern (way): the Kruskal-Wallis test and the Friedman test were used to make the analysis and it was observed that there is a significant difference amongst the various causes of road traffic accidents with respect to types of offences recorded for the years 2010-2015, out of the* ***2210*** *Road traffic offences recorded for the 5years, Sign Light Violation accounted for 30.72% as the Road Traffic offence with the highest contribution to Road Traffic accident in Adamawa state for the years under review, Seconded by Loss of Control with 16.70% and Dangerous Driving with 15.97%, also the Road Traffic offence with the least contribution to Road Traffic Accidents in the Statewas Use of Phone While Driving with 0.23%.*

KEYWORDS:*Road traffic offence, Kruskal-Wallis test, Friedman test, Wilcoxon Rank sum test.*

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I. INTRODUCTION

Road traffic accident occurs when a vehicle collides with another vehicle, pedestrian, animal, road debris, or other stationary obstruction, such as a tree or utility pole. Road traffic accidents occur worldwide but the incidence is more in developing countries. Annually, about 1.25 million people die each year as a result of road traffic crashes. Road traffic injuries are the leading cause of death among young people, aged 15–29 years. 91% of the world's fatalities on the roads occur in low-income and middle-income countries, even though these countries have approximately half of the world's vehicles. Half of those dying on the world's roads are "vulnerable road users": pedestrians, cyclists and motorcyclists. Without action, road traffic crashes are predicted to become the 7th leading cause of death and will result in the deaths of around 1.9 million people annually by 2030 (W.H.O 2016).

Nigeria has the status of a developing country where road facilities are grossly inadequate to carter for the teeming population of road users.In Nigeria today, hardly a day goes by without the occurrence of a road traffic accident leading to generally increasing incidence of morbidity and mortality rates as well as financial cost to both society and the individual involved. Information on some of these traffic accidents get to the news rooms of media houses and are aired while majority goes unreported. Nigeria has the highest road accidents rate as well as the largest number of death per 10,000 vehicles (Sheriff, 2009). One may be tempted to believe that the level of awareness on the causes of road traffic accidents is very low among Nigerians. Put differently, Nigerian roads have become killing fields without protection for their users. Travelers heave a sigh of relief if they make their destinations (Eze, 2012). Contrary to the general belief that Nigerians possess very low level of awareness on the causes of road traffic accidents, previous research has shown that Nigerians know quite a lot about what could cause road traffic accidents (Asalor, 2010).

Adamawa state a slight heavily motorized state with poor road conditions and transport systems has a high rate of RTAs and the tendency is on the increase. Frequently, reported road traffic offences have a relationship with the number of accidents and the contribution of each to road traffic accidents. Since, there is a need to reduce Road Traffic accidents which results into injury, death and loss of property. The pattern and frequencies of these offences are not the same, and therefore there is need for analysis to ascertain which ones occur more so as to reduce them.

Therefore, the aim of this paper is to use the nonparametric approach to data analysis on road traffic accidents to compare amongst the various types of road traffic offences and to point out which one(s) are more responsible for road accidents in the state during the periods under review.

II. REVIEW OF RELATED WORKS

Various studies have addressed the different aspects of RTAs using one or two Non parametric method(s), with most focusing on predicting or establishing the critical factors influencing injury severity. Goswami and Sonowal (2011) did a statistical analysis of road traffic accident data. They found that human characteristics (rush and negligence) make 95.38% of the total RTAs. 60% of the accidents were recorded during day time (6 AM to 6 PM). The peak time was between 12 PM to 6 PM (38.46%). The highest numbers of accidents (32.30%) were observed in the heavy rainy season during the months of July – September.Mohammad (2009) conducted a statistical analysis for road traffic accidents and associated casualties. The research found out that pedestrians are highly involved in the casualty figures. Fatal hit pedestrian is the main collision type accident. Cities have higher accident and casualty rates than non-cities (divisions/ districts, excluding cities). National highways are the main venues of accidents and casualties. Heavy vehicles including buses and trucks are predominantly involved in casualty accident.

In Nigeria, trauma is the main reason for emergency room visits and road traffic accidents are responsible for the majority of deaths. The overall road traffic injury rate is about 41 per 1000 population and mortality from road traffic injuries is about 1.6 per 1000 population. This is significant when the fact that majority of these injuries and deaths can be prevented. It becomes worrisome with the fact that the incidence is increasing (Eze, 2012).

III. METHOD AND MATERIALS

For this paper, the statistical method for data analysis used is the nonparametric method under which the Kruskal-Wallis test, Wilcoxon Rank Sum test and the Friedman's test were used for data analysis.Data on recorded Road Traffic Accidents were collected from the Federal Road Safety Corps head office Yola, for 5 years period (2010-2015)

Kruskal-Wallis Test (H-Statistic):

This is a non-parametric test for k (k ≥ 2) independent random samples of possibly different sizes. It is considered as an extension of the of the Wilcoxon Rank sum test for two independent samples. It is used for comparing two or more samples that are independent, and that may have different sample sizes, and extend the test to more than two groups. The Kruskal-Wallis test enjoys the same power property relative to the Analysis of Variance (ANOVA) for the F test and also as a direct counterpart to the Chi-Square test as well as the one way analysis of variance (ANOVA). The Kruskal-Wallis test as proven is almost as powerful as the F test (if not better). Since the test is a nonparametric test, the Kruskal-Wallis test assumes no distribution (normal) of the residual.

Test of hypothesis:

$$H_0: M_1, M_2, \dots, M_k Vs H_1: M_i \neq M_j for some i \neq j$$

Where

M_i is Median traffic offences $i = 1,2,\dots,k$

Test statistic:

As proposed by Kruskal and Wallis (1952)

$$H = \frac{12}{N(N+1)} \sum_{i=1}^{k} \left(\frac{R_i^2}{n_i}\right) - 3(N+1) \quad (1)$$

They showed that if no n_i is small, then H is distributed asymptotically as the chi-square with degrees of freedom (d.f) = (k-1).

When k is small, say k=3, and the n_i are also small, the chi-square approximation is not good. For such cases, exact probabilities have been tabulated.

When ties occur, a correction has to be made. The corrected H- statistics is defined as

$$H_c = \frac{H}{\left[1 - \frac{\sum(t^3 - t)}{(N^3 - N)}\right]} \quad (2)$$

Where;

t = number of observations tied for a given rank in each sample group.

n_i = number of observations in group i

N = the total number of observation across all groups.

R_i = Sum of ranks of observation for each group i.

Rejection region:

The exact tabulated values for k < 3 is checked in the tabulated Kruskal-Wallis table and for k ≥ 3 the exact probability value (tabulated value(s)) is checked up in the Chi Square table.

We reject H_o in favor of H_1 if H statistic is > the tabulated value, otherwise we do not reject the null hypothesis H_o at the given α level of significance.

IV. CONCLUSION

If the H statistic is not significant, then there is no evidence that there is a significant difference between the samples. However, if the H statistics is significant then at least one sample differ significantly from another sample.

Friedman test

The Friedman test is for comparing three or more related samples and which makes no assumptions about the underlying distribution of the data.

The Friedman test statistic is used to determine if k groups have been selected from a population having equal medians it is the most widely used procedure for transforming ratio and interval data in more than two independent samples to the ordinal measurement scale, Friedman (1937).

Test of hypothesis:

$$H_0: M_1, M_2, \dots, M_k Vs H_1: M_i \neq M_j for some i \neq j$$

Where

M_i is Median traffic offences $i = 1,2, \dots, k$

Test statistic:

The test statistics for the Friedman test is given by, F_k.

As proposed by Friedman (1937)

$$F_k = \frac{12}{\mathrm{rc}\,(\mathrm{c}+1)} \sum_{\mathrm{j}=1}^{\mathrm{c}} R_i^2 - 3\mathrm{r}\,(\mathrm{c}+1) \qquad (3)$$

If ties exist in the ranks, we use

$$F_{ck} = \frac{\left[\frac{12}{\mathrm{rc}\,(\mathrm{c}+1)} \sum_{\mathrm{j}=1}^{\mathrm{c}} R_i^2 - 3\mathrm{r}\,(\mathrm{c}+1)\right]}{\left[1 - \frac{\mathrm{w}}{\mathrm{rc}\,(\mathrm{c}^2-1)}\right]} \quad \text{or} \quad \frac{F_k}{\left[1 - \left[\frac{\mathrm{w}}{\mathrm{rc}\,(\mathrm{c}^2-1)}\right]\right]} \qquad (4)$$

Where,

R_i^2= is the square of ranks for each sample.

r = number of rows.

c = number of columns

$\mathrm{W} = (\mathrm{ti}^3 - \mathrm{ti})$

t_i= number of ties at each particular value .

Rejection region:

For any selected level of significance α, we reject the null hypothesis H_o if the computed value of F_k is greater than $\chi^2 u$, i.e. the upper tailed critical value for the chi square distribution having $(c-1)$ degrees of freedom otherwise do not reject Ho.

Conclusion:

If the computed value of F_k is not significant, then there is no evidence that there is a significant difference between the samples. However, if the computed value of F_k is significant then at least one sample differ significantly from another sample.

Wilcoxon Rank sum test

The Wilcoxon Rank Sum test is a nonparametric alternative to the two sample t-test.

When the assumptions of the t-test are violated or are partially fulfilled then the Wilcoxon Rank Sum test which makes fewer or less stringent assumption than the t-test is likely to be more powerful in detecting the existence of significant differences between samples (2 samples) than the t-test (parametric counterpart), Siegel (1956).

Moreover, even in situation where the parametric assumptions of the t-test are satisfied, the Wilcoxon Rank Sum test has proven to be most powerful.

Wilcoxon Rank Sum test (2 samples) is used to show the significance differences that exist between sample pairs when a significant result has been obtained from using the Kruskal-Wallis test statistic and the Friedman's test. It is natural to use the test for this purpose.

Test of hypothesis:

$$H_0: M_1, M_2, \dots, M_k Vs H_1: M_1 \neq M_2$$

Where

M_i is Median traffic offences $i = 1,2$

Test statistic:

As proposed byWilcoxon(1945)

If the number of observations/pairs is such that $\frac{\mathrm{n}(\mathrm{n}+1)}{2}$, is small (n <20), the test statistics is,

$$W = \sum_{\mathrm{i}=1}^{\mathrm{n}} R_i^+ \qquad (5)$$

Where

R_i^+= All positive ranks.

If the number of observations/pairs is such that $\frac{n(n+1)}{2}$, is large enough (n > 20), a normal approximation can be used as proposed by Wilcoxon (1945)

$$Z_w = \frac{W-\mu_w}{\sigma_w} \quad (6)$$

Where

$$\mu_w = \frac{n(n+1)}{4} \text{and} \quad (7)$$

$$\sigma_w = \sqrt{\frac{n(n+1)(2n+1)}{24}} \quad (8)$$

Where

W= Sum of positives or negative ranks.

n = the number of pairs of observations in the sample.

Dealing with ties:

There are two types of tied observations that may arise when using the Wilcoxon Rank Sum test:

i. Observations in the sample may be exactly equal to M (i.e. 0 in the case of paired differences). Ignore such observations and adjust n accordingly.

ii. Two or more observations/differences may be equal. If so, average the ranks across the tied observations and reduce the variance $\frac{t^3-t}{48}$ for each group of t tied ranks.

Decision rule:

i. When the number of pairs is small (n < 20), we reject the null hypothesis (H_o) if calculated (W) > tabulated ($W_{n,\alpha}$) value from the Wilcoxon table, otherwise we do not reject the null hypothesis (H_o) at the specified level of significance.

ii. When the number of pairs (> 20), we use the normal approximation i.e. we reject the null hypothesis (H_o) if calculated (Z_w) > tabulated ($Z_{n,\alpha}$) value from the normal Z table. Otherwise do not reject the null hypothesis (H_o) at the specified level of significance.

V. ANALYSIS, RESULTS AND DISCUSSIONS

TABLE 1:Table of reported Road Traffic offences in percentage

S/NO	Type of Road Traffic Offences	Total road traffic offences reported (2010-2015)	Percentage of occurrence (%)
1.	SPV	117	5.30
2.	UPWD	5	0.23
3.	TBT	113	5.11
4.	LOC	369	16.70
5.	MDV	53	2.40
6.	BFL	6	0.27
7.	OVL	46	2.08
8.	DOT	76	3.44
9.	WOT	33	1.49
10.	DGD	353	15.97
11.	BRD	21	0.95
12.	RTV	162	7.33
13.	OBS	87	3.94
14.	DAD	43	1.95
15.	PWR	8	0.36
16.	SLV	679	30.72
17.	OTH	39	1.76
	TOTAL	**2210**	**100**

Based on the data on Road Traffic Accidents in Adamawa State (by type of offence and year) for the years 2010-2015 from the Federal Road Safety Corps, a total of 2,210 Road Traffic Offences were recorded. The analyses were carried out using SPSS package. The variables investigated are the number of offences associated with each offence type.

TABLE 2:Test Statistics (Kruskal Wallis)

N	6
Chi-Square	77.374
D.f	16
Asymp. Sig.	.000

Conclusion: From the above test statistic table, since H statistic P-value < 0.05, we then do not have enough evidence to accept the null hypothesis and conclude that the results suggest differences amongst the types of offence.

Friedman Test

TABLE 3:Test Statistics (Friedman test)

N	6
Chi-Square	83.032
Df	16
Asymp. Sig.	.000

Conclusion: From the above test statistic table, since H statistic P-value < 0.05, we then do not have enough evidence to accept the null hypothesis and conclude that the results suggest differences amongst the types of offence.

Using the Wilcoxon Rank sum Test as a post HOC for pairwise comparison

TABLE 4: Test statistic Table for post hoc using Wilcoxon Rank Sum test

Compared pairs of road traffic offences		Z values	Asymp sig (2- tailed)	Significant compared to P-value of 5%
SFV (VS)	USWD	-2.023	0.043	Yes
	TBT	-0.943	0.345	No
	LOC	-1.992	0.046	Yes
	MDV	-0.210	0.833	No
	SRL	-1.992	0.046	Yes
	OVL	-1.261	0.207	No
	DOT	-0.526	0.599	No
	WOT	-1.153	0.249	No
	DGD	-2.082	0.035	Yes
	SRD	-2.023	0.043	Yes
	RTV	-0.943	0.345	No
	OBS	-0.677	0.498	No
	DAD	-0.734	0.463	No
	FWR	-2.023	0.043	Yes
	SLV	-2.082	0.035	Yes
	OTH	-0.946	0.344	No
USWD (VS)	TBT	-2.214	0.027	Yes
	LOC	-2.207	0.027	Yes
	MDV	-2.207	0.027	Yes
	SRL	-0.577	0.564	No
	OVL	-2.207	0.027	Yes
	DOT	-2.264	0.024	Yes
	WOT	-2.226	0.026	Yes
	DGD	-2.201	0.028	Yes
	SRD	-2.023	0.043	Yes
	RTV	-2.214	0.027	Yes
	OBS	-2.214	0.027	Yes
	DAD	-2.214	0.027	Yes
	FWR	-1.732	0.083	No
	SLV	-2.201	0.028	Yes
	OTH	-2.207	0.027	Yes
TBT (VS)	LOC	-2.201	0.028	Yes
	MDV	-2.207	0.027	Yes
	SRL	-2.226	0.026	Yes
	OVL	-2.207	0.027	Yes
	DOT	-2.030	0.043	Yes
	WOT	-2.003	0.045	Yes
	DGD	-2.201	0.028	Yes
	SRD	-2.207	0.027	Yes
	RTV	-2.201	0.028	Yes
	OBS	-2.207	0.027	Yes
	DAD	-2.207	0.027	Yes
	FWR	2.226	0.026	Yes
	SLV	-1.997	0.046	Yes
	OTH	-2.214	0.027	Yes
LOC (VS)	MDV	-2.201	0.028	Yes
	SRL	-2.207	0.027	Yes
	OVL	-2.201	0.028	Yes
	DOT	-2.207	0.027	Yes
	WOT	-2.207	0.027	Yes
	DGD	-0.314	0.753	No
	SRD	-2.201	0.028	Yes
	RTV	-2.214	0.027	Yes
	OBS	-2.201	0.028	Yes
	DAD	-2.226	0.026	Yes
	FWR	-2.207	0.027	Yes
	SLV	-1.787	0.074	No
	OTH	-2.201	0.028	Yes
MDV (VS)	SRL	-2.214	0.027	Yes
	OVL	-1.687	0.092	No
	DOT	-2.207	0.027	Yes
	WOT	-0.949	0.343	No
	DGD	-2.207	0.027	Yes
	SRD	-2.207	0.027	Yes
	RTV	-2.201	0.028	Yes
	OBS	-2.226	0.026	Yes
	DAD	-1.857	0.063	No
	FWR	-2.214	0.027	Yes
	SLV	-2.023	0.043	Yes

	OTH	-1.367	0.172	No
SRL (VS)	CVL	-2.032	0.042	Yes
	DOT	-2.226	0.026	Yes
	WOT	-2.060	0.039	Yes
	DGD	-2.201	0.028	Yes
	SRD	-1.753	0.080	No
	RTV	-2.207	0.027	Yes
	OBS	-2.207	0.027	Yes
	DAD	-1.890	0.059	No
	FWR	-0.816	0.414	No
	SLV	-2.201	0.028	Yes
	OTH	-1.214	0.027	Yes
CVL (VS)	DOT	-2.232	0.026	Yes
	WOT	-0.954	0.340	No
	DGD	-2.207	0.026	Yes
	SRD	-1.897	0.027	Yes
	RTV	-2.201	0.058	No
	OBS	-2.226	0.026	Yes
	DAD	-0.962	0.336	No
	FWR	-2.207	0.027	Yes
	SLV	-2.201	0.028	Yes
	OTH	-0.405	0.683	No
DOT (VS)	WOT	-2.014	0.044	Yes
	DGD	-2.201	0.028	Yes
	SRD	-2.226	0.026	Yes
	RTV	-2.207	0.027	Yes
	OBS	-1.382	0.167	No
	DAD	-2.207	0.027	Yes
	FWR	-2.226	0.026	Yes
	SLV	-1.992	0.046	Yes
	OTH	-2.207	0.027	Yes
WOT (VS)	DGD	-0.201	0.028	Yes
	SRD	-2.736	0.461	No
	RTV	-2.032	0.042	Yes
	OBS	-1.897	0.058	No
	DAD	-0.680	0.496	No
	FWR	-2.226	0.026	Yes
	SLV	-2.201	0.028	Yes
	OTH	-0.946	0.344	No
DGD (VS)	SRD	-2.201	0.028	Yes
	RTV	-2.201	0.028	Yes
	OBS	-2.201	0.028	Yes
	DAD	-2.201	0.028	Yes
	FWR	-2.201	0.028	Yes
	SLV	-1.787	0.074	No
	OTH	-2.207	0.027	Yes
SRD (VS)	RTV	-2.201	0.028	Yes
	OBS	-2.207	0.027	Yes
	DAD	-2.032	0.042	Yes
	FWR	-2.032	0.042	Yes
	SLV	-2.207	0.027	Yes
	OTH	-2.003	0.045	Yes
RTV (VS)	OBS	-2.201	0.028	Yes
	DAD	-2.207	0.027	Yes
	FWR	-2.207	0.027	Yes
	SLV	-1.992	0.046	Yes
	OTH	-2.226	0.026	Yes
OBS (VS)	DAD	-2.207	0.027	Yes
	FWR	-2.207	0.027	Yes
	SLV	-1.992	0.046	Yes
	OTH	-2.201	0.028	Yes
DAD (VS)	FWR	-2.232	0.023	Yes
	SLV	-2.207	0.027	Yes
	OTH	-0.317	0.751	No
FWR (VS)	SLV	-2.201	0.028	Yes
	OTH	-2.214	0.027	Yes
SLV (VS)	OTH	-2.207	0.027	Yes

From TABLE 4**,** we reject the null hypothesis in situation that are indicated as **Yes** and conclude that the two compared Road traffic offences differ reliably in occurrence from each otherat the 5% level of significance also, we do not reject the null hypothesis in cases indicated as**No** and conclude that two compared Road traffic offences do not differ in occurrence from each other at the 5% level of significance.

TABLE 5:Table for Acceptance and Rejection after the Wilcoxon Rank sum test

OFFENCES	SLV	DGD	LOC	SPV	UPWD	TBT	MDV	BFL	OVL	DOT	WOT	BRD	RTV	OBS	DAD	PWR	OTH
SLV	0	A	A	R	R	R	R	R	R	R	R	R	R	R	R	R	R
DGD		0	A	R	R	R	R	R	R	R	R	R	R	R	R	R	R
LOC			0	R	R	R	R	R	R	R	R	R	R	R	R	R	R
SPV				0	R	A	A	R	A	A	A	R	A	A	A	R	A
UPWD					0	R	R	A	R	R	R	R	R	R	R	A	R
TBT						0	R	R	R	R	R	R	R	R	R	R	R
MDV							0	R	A	R	A	R	R	R	A	R	A
BFL								0	R	R	R	R	A	R	A	A	R
OVL									0	R	A	A	R	R	A	R	A
DOT										0	R	R	R	A	R	R	R
WOT											0	A	R	A	A	R	A
BRD												0	R	R	R	R	R
RTV													0	R	R	R	R
OBS														0	R	R	R
DAD															0	R	A
PWR																0	R
OTH																	0

VI. DISCUSSION

Records of reported Road traffic offences in Adamawa state for 2010-2015 was collected from the Federal Road Safety corps Yola and analysis were carried out using the Non-parametric method.

TABLE 1 Shows the percentage (%) of occurrence of each Road Traffic Offence out of a total of **2210** Road Traffic Offences that have occurred in Adamawa state over the Five (5yrs) period been considered, using the percentage of each occurrence, it is been deduced that the highest Road Traffic Offence that occurred in the state proved to be Sign Light Violation (SLV) with a percentage occurrence of 30.72%, seconded by Loss of Control (LOC) with 16.70% followed by Dangerous Driving (DGD) with 15.97%. Also the Road Traffic Offence with the lowest occurrence rate as indicated by the percentage table proved to be Use of Phone While Driving (UPWD) with 0.23%.

As shown from TABLE 2 and 3of which the analysis performed using SPSS for both the Kruskal Wallis test and the Friedman test shows that in each case, the null hypothesis was rejected at the 5% level of significance i.e. the Statistic (H and F)'s Values < P-value (0.05) and hence, the various Road Traffic Offences do not occur in the same pattern.

Furthermore, using the Wilcoxon Rank Sum test for pairwise comparison amongst the various Road Traffic offences was carried to check the validity of the result in TABLE 1 of which in each pairwise comparison, as shown in TABLE 4 using the P-values against the 5% level of significance, some of the comparisons (those labeled as **Yes**) showed that the compared offences differ reliably from each other hence, as shown in TABLE 5,the null hypothesis is rejected in such cases indicating that the compared occurs do not occur in the same way. Most notably are the three (3) Road Traffic offences with the Highest occurrence rates (SLV=30.72%, LOC=16.70%, DGD=15.97%) when compared to other offences with lesser percentage of occurrences, as in TABLE 5, the null hypothesis are rejected in each comparison indicating that they have indeed the highest occurrence rates. While comparisons (those labeled with **No**) showed that the compared offences do not differ reliably from each other as shown in TABLE 4,As in cases where the compared offences have the same or almost the same percentage of occurrence (TBT=5.11, SPV=5.30 etc.), hence in such cases, as shown in TABLE 5,the null hypothesis is not rejected indicating that the compared offences occur in the same pattern.

VII. CONCLUSION

In this paper, the nonparametric method was employed to analyze data on Road traffic Accidents in Adamawa state of Nigeria using the various Road Traffic offences for the years 2010-2015 of which the road traffic offence with the highest contribution to road accidents proved to be SLV with a percentage occurrence of 30.72%, seconded by LOC with 16.70% and followed by DGD with 15.97%, also the Lowest Road Traffic Offence with the lowest occurrence rate as indicated by the percentage table proved to be UPWD with 0.23%. Road traffic offences are predictable and therefore preventable.

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