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Effects of Driver's Behavior on Traffic at Lagos Bus Stop and Amadi-Ama Intersections in Port-Harcourt Metropolis.

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Abstract
The purpose of this study was to investigate the behaviors of drivers that contribute to traffic congestion at different intersections in Port Harcourt. Data was collected through direct field investigation and used to show traffic volume and relative bottleneck speed characteristics at Lagos bus stop and Amadi-ama intersections. The survey was limited to these two locations, and 200 questionnaires were distributed among a sampled group of private and commercial drivers, passengers, pedestrians, and traffic officers. Using T-test statistics, researchers analyzed respondents' answers regarding various motorist behaviors that contribute to traffic congestion, such as indiscriminate stopping, roadworthiness, drug and alcohol use, and vehicles parked on driveways. The data showed a significant relationship between drivers' behavior and traffic congestion at these intersections. In addition, bottleneck speed analysis revealed a drag in speed, averaging about 7km/hr within the bottleneck zones. The T-test analysis showed t-scores greater than 7 for each independent variable at these intersections, exceeding the threshold z-value of 1.96 for a 5 percent significance level. This supports the alternate hypothesis that driver behavior has a significant effect on traffic congestion. Based on the study's findings, it is recommended that traffic regulations be fully implemented without social class bias, and stringent actions on violators be introduced.
Keywords: *Drivers Behaviour, Traffic Congestion, Traffic Flow. Bottleneck speeds, intersections*

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I. INTRODUCTION

Traffic congestion within the garden city of Port Harcourt as it is often called, and its road networks have in time past, and even presently been a major challenge. Although, with some relief as a result of various improvements done to the transport infrastructures, however, the present road traffic congestion levels captured within its roadway networks are still unimaginable. This is observed within major cities in Nigeria, and even the city of Port Harcourt, as road traffic congestion now is a predominant challenge (Agaviezor, et al., 2022). The growth levels of motorists observed within the city have risen because of the observed increased population growth size of urban dwellers within the city. One main reason for such growth levels as highlighted by Otto & Awari (2022), was the eminent quest for a better living by individuals, which in turn renders the city of Port Harcourt vulnerable to unsustainable growth in traffic and congestion. An increment of about 37.1% in traffic flow levels was forecasted between the years 2012 to 2022, invariably pointing to the fact that a total of 217,360 cars are expected to ply through the city's road network Dienye (2014). Unarguably, with such an increment in the number of motorists observed, there is a certain possibility of a rebound effect on the congestion levels also observed as this would increase the traffic illiteracy levels and the carefree attitude seen amongst various motorists due to the lack of proper law enforcement strategies, which invariably seems to frustrate any improvements in the transport infrastructures/facilities. No doubt there is an underlying relationship between the growing motorist size and the observed road traffic congestion challenge, but however, Ukpatal (2012) highlighted some factors, perceived to aid road traffic congestion as drivers' poor habits. This was also mentioned by Emenike (2017), to be a root cause of road traffic congestion, as various motorists indulge in poor driving behaviors as a result of personal habits. Based on these arguments, a study by Ito & Kaneyasu (2017), examined the above link between drivers' behavior and the observed road traffic congestion and from their observations, established a model which was referred to as the driver's model, effectively, this model was able to predict road traffic congestion trends, using various observed changes in the habits of motorists as its inputs. In the light of the stated matter also, their studies concluded based on relevant findings that in predicting road traffic congestion the intermediate phase between the free travel phase and the traffic congestion phase had to be fully understood and effectively detected. From their research after fully gaining this understanding from their analysis, a driver's model that forecasts traffic congestion was proposed based entirely on the observed driver's behavior. One of these various categories of behaviors observed in motorists as highlighted by oluwaseyi et al. (2020), was parked vehicles on the driveway. Notably, such behaviors are observed to drastically reduce the effective geometrical width of the roadway, thereby inherently reducing the designed operational capacity of the roadway. Also observed about the subject, was the fact that a tenth of vehicles used by commercial long-distance drivers were not road-worthy (Chinedu, 2018), which in most cases increases the pollution intensity in the atmosphere as well as the possible occurrence of bottlenecks by breaking down vehicles due to poorly maintained vehicles by drivers which is also a behavioral side effect. Given the undisputed fact that driver's behavior is a key inclusive factor that leads to the generation of road traffic congestion, which also has from previous works lacked the relevant in-depth descriptive study needed to understand the full magnitude of its influence in the present-day road traffic congestion challenges. It is now even more necessary that this subject should be fully studied with relevant data generated and analyzed. As such, in other to fully achieve this, the objectives of this research were to;

i. Determine the traffic volume at each intersection using the volume survey data.
ii. Evaluate the average flow and bottleneck speed characteristics at each intersection.
iii. Evaluate the effects of driver's behavior in traffic congestion using a statistical approach.

II. MATERIALS AND METHODS

2.1 MATERIALS

To fully carry out the field investigation needed for this study, a data entry sheet, a writing pen, a stopwatch, and a measuring tape were all utilized.

2.2 METHODS

2.2.1 T-test and Bottleneck Speed Algorithms

The study employed the use of various primary data sources, collected at each of the selected intersections studied. In other to fully validate the study's claim, a well-structured questionnaire was administered to a total of 200 respondents comprising various categories of road users which includes, private and commercial motorists, pedestrians, passengers, and traffic officers. Within each questionnaire were listed six distinct categories of various observed driver behaviors commonly encountered on our roadways. These categories were then ranked based on their critical or non-critical influence on roadway traffic by each respondent. After which, the results obtained were then subjected to a hypothetical statistics test, of which for this study the T-test was employed. This test was chosen since it had the dual ability of validating the sample size and also effectively weighing out the strength of each category considered, to provide a basis for its acceptance or rejection based on a standardized threshold. A summary of the stages and formulas used are as follows;

i. Extraction of Responses

The initial phase of the statistical procedure involves extracting the primary raw data from the respondents at each location and translating them into tabulated results using spreadsheets for further analysis. The independent variables so tabulated are represented in weighted values, of numbers ranging from (0-100) based on their critical, non-critical, and not applicable (i.e., not necessary) responses obtained. It is significant to state that for the purpose of this study the following weighted ranks would be employed;

0 = not necessary (equivalent to C)
1-59 = not critical (equivalent to B)
60-100 = critical (equivalent to A)

ii. Determination of Sample Mean, Standard deviation and Samples' distribution (Characteristics of sample)

The Samples' mean and standard deviation for each independent variable category will be obtained using the appropriate equations of arithmetic mean and deviation (Wadsworth, Jr. 1990). Also, the samples characteristics, which is based on its distribution from the responses obtained, would be based on their respective kurtosis (Kenney and Keeping, 1962:102-103, Darlington, 1970:19-22, Abramowitz and Stegun, 1972:928, Moors, 1986:283-284, Dodge and Roussos, 1999:267-269) and standard error Kurtosis (Tabachnic and Fidel, 1966).

$$\mu = \frac{1}{N}\sum_{i=1}^{K} Xi \quad (1)$$

Where, μ = sample mean of each independent variable for each response
Xi = weightings of each independent variable for each response
N = sample size of each independent variable for each response

$$\sigma = \sqrt{\frac{1}{N-1}\sum (Xi - \mu)^2} \quad (2)$$

Where, μ = sample mean of each independent variable for each response
Xi = weightings of each independent variable for each response
N = sample size of each independent variable for each response
N-1 = unbiased estimator (Wadsworth, jr. 1990)
σ = standard deviation for each independent variable for each response

$$\beta = \frac{\sum(X - \mu)^4}{N\sigma^4} - 3 \quad (3)$$

Where, μ = sample mean of each independent variable for each response
X = weightings of each independent variable for each response
N = sample size of each independent variable for each response
σ = standard deviation for each independent variable for each response
β = kurtosis of each independent variable for each response

iii. Independent T-Test Analysis

The independent t-test would be carried out in other to validate the hypothetical questions stated, such that the purpose of this study is established. This procedure would involve various steps or phases, in other to arrive at the final t-test scores. However, the procedure starts with an initial analysis of the means and standard deviations for each independent variable, before applying the theoretical equations for the t-test analysis. These analyses are effectively carried out on an excel based spread sheet for simplification and accuracy, based on the background theory of the t-test. Various required steps (5 steps in all) will be appropriately carried out, after which, the final t-test scores will be compared with a standard Z score of 1.96, representing a 5 percent risk in error of rejecting the null hypothesis for the alternate hypothesis. In other words, from the analysis, a score equal to or greater than 1.96, implies that the null hypothesis is rejected for the alternate hypothesis

$$Z = \frac{\mu_c - \mu_n}{\sqrt{\frac{\sigma_c}{N_c} + \frac{\sigma_n}{N_n}}} \quad (4)$$

Where, μ_c = sample mean for the critical responses
μ_n = sample mean for the not-critical responses
σ_c = standard deviation for the critical responses
σ_n = standard deviation for the not-critical responses
N_c= sample size for the critical responses
N_n= sample size for the not-critical responses

and vice versa.

iv. Traffic flow Analysis

The traffic studies conducted was based on the maximum traffic flow observed at the selected intersections and as such considered mainly the morning (7:00am – 10:00am) and evening peak traffic periods (4:00pm – 7:00pm). The traffic volume count considered various classes of vehicles, which were converted to their equivalent PCU values respectively based on the Transport and Road Research Laboratory (1980) guidelines. Adopting the Lighthill and Whitham theory (1955), which was based on the view point that traffic flow can be understood by studying the characteristics of fluids in motion, the various speeds at the bottle neck region, were obtained for traffic flows greater than the capacity of the bottleneck region, by evaluating the slopes between the flow (Q) and concentration (K) values from the analysis.

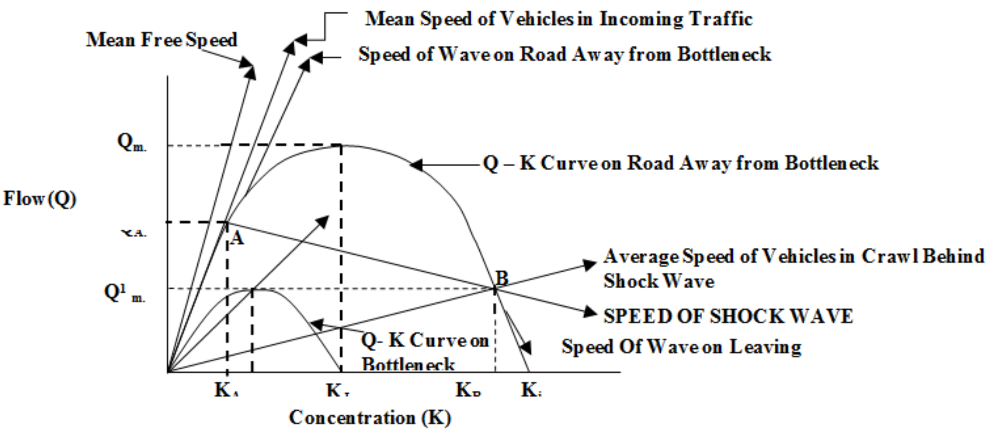

Figure. 1 Q – K Curves of Bottleneck, with Flow Greater Than Bottleneck

From the diagram above, the intersect at (A) represents a flow (Q_A) which is greater than the capacity of the bottle (Q_{max}). Following this, the vehicles speed through the bottleneck region reduces from $\frac{Q_A}{K_A} - \frac{Q_{max}}{K_J}$. The point labeled (B) represents the condition of flow, on the road away from the bottleneck region with its density the same as the bottleneck capacity (Q'_{max}). However due to the shockwave as a result of the bottleneck, vehicles approaching the bottleneck region experience a reduced speed called the crawl speed, which is far lower than the speed through the bottleneck region represented by the slope $\frac{Q'_{max}}{K_B}$. This then proves that the crawl speed is far lower than the speed observed through the bottleneck itself. The speed as a result of the shock wave is shown by the slope of the line AB;

$$AB = \frac{Q_A - Q^I_{max}}{K_B - K_A} \quad (5)$$

In solving the mathematical traffic problems related to this research, the two major equations used are:
Jamming concentration,

$$K_j = \frac{1000}{s} \quad (6)$$

Traffic volume/ flow,

$$Q = \frac{V_{sf \times K_j}}{4} \quad (7)$$

Where:
Kj = Jamming concentration.
S = Average spacing.
Q = Traffic volume/ flow
Vsf = Average mean speed

III. RESULTS AND DISCUSSIONS

Table 1, gives a summary of both the average traffic flow and speed values for vehicles at the selected intersections.

Table 1: Summary Table of The Average Traffic Flow and Bottleneck Speeds at The Selected Intersections

Location	Days	Free flow speed (Km/hr)	Spacing (m)	Density (K) veh/hr	Jam density (k_j) veh/hr	Observed flow(Q)	Maximum flow (Q_{max})	Minimum flow (Q_{min})	Speed before bottle neck (Km/hr)	Speed at bottle neck (Km/hr)	Speed after bottle neck (Km/hr)
LAGOS	Mon	61	6	179	358	2080	5483	2742	7	31	52
	Tue	59	6	179	358	2066	5232	2616	7	29	50
	Wed	62	6	179	358	2000	5501	2750	7	31	52
	Thurs	61	6	179	358	2045	5483	2742	7	31	52
	Fri	59	6	179	358	2005	5307	2653	7	30	50
AMADI	Mon	62	6	169	338	2133	5226	2613	8	31	52
	Tue	62	6	166	331	2037	5141	2570	8	31	53
	Wed	65	6	169	338	2105	5473	2736	8	32	55
	Thurs	61	6	169	337	2021	5147	2573	8	30	52
	Fri	63	6	177	354	2089	5516	2758	7	31	53

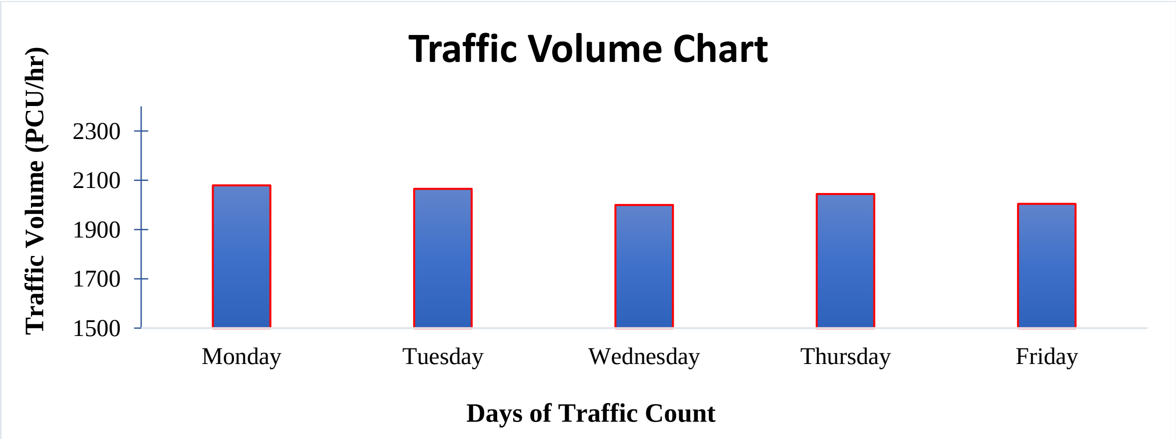

Figure 1: Average Peak-Hour Traffic Volume at Lagos Bus stop Intersection

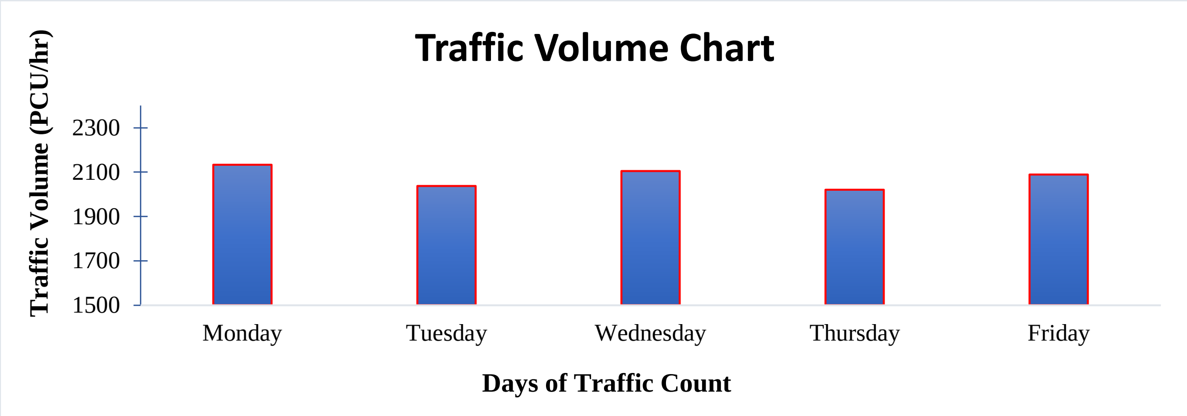

Figure 2: Average Peak-Hour Traffic Volume at Amadi-Ama Intersection

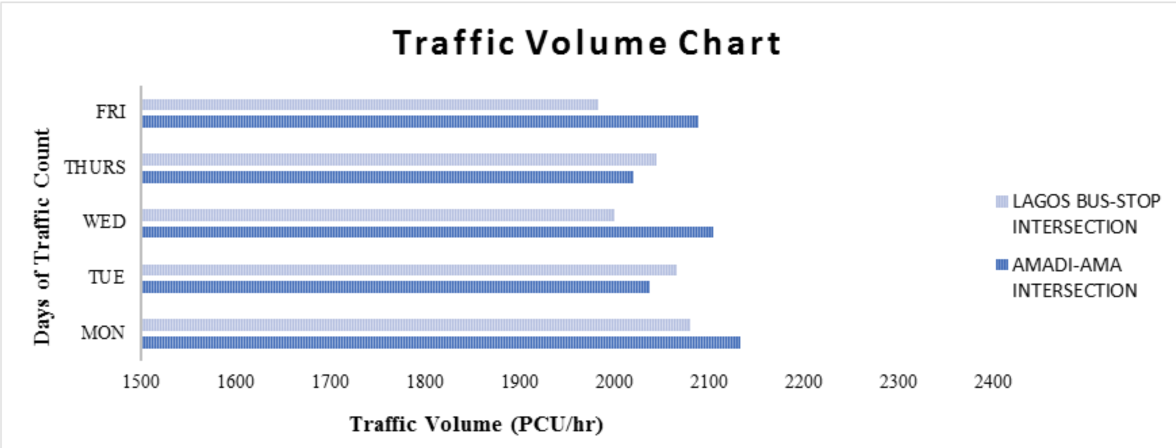

Figure 3: Summary of the Average Traffic Peak-Hour Volume at the Selected Intersections

From the data given above, the observed traffic volumes at the intersections were more as a result of their spatial locations within the city. Situated in the heart of some of the most commercially driven environs, these intersections are noted to attract lots of trips with values ranging from 2000PCU/hr -2100PCU/hr, in addition to the traffic volumes attracted from moderately dense residential areas at proximity to their locations. The highest traffic volumes were observed to occur mostly on Mondays for both intersections, with slight variations in volume for the other weekdays depending on the intersection studied. Figures 1 and 2, however, give a diagrammatic representation of the observed average peak-hour traffic volumes at the selected intersections.

Also From Table 1, the free flow speed was observed to occur at values ranging from 59-63km/hr at both intersections. Although, these speeds were later seen to drastically decelerate to values of 7km/hr at the Lagos bus stop intersection, and 7-8km/hr at the Amadi-ama intersection, evidently revealing the congested state of these intersections. These decelerations in speed values resulting in a substantial time lag, was because of an overall reduction in capacity of these intersections to accommodate vehicular traffic due to various drivers' behavior. These behaviors by motorists/drivers; behaviors like Indiscriminate stopping of vehicles on the driveway, vehicles parked on the driveway, road worthiness, and violations of traffic rules were top ranked at the Lagos bus stop intersection, while behaviors like wrong maneuvering, roadworthiness, and violations of traffic rules topped the list at the Amadi-ama intersection. Otto & Awari (2022) in a study also observed same similar trend in deceleration at the bottleneck region, and among the major factors listed was the human behavioral factor. Notably, both speeds were seen to gradually increase through the bottleneck region with speed values of 30-32km/hr and then further accelerated in speed to values of about 50-55km/hr away from the bottleneck region at both intersections. Figure 3 however, gives a summarized plot of both intersections' traffic volumes for various working days in the week.

Tables 2, 3, and Figure 4 display the results of the descriptive statistics for all independent variables considered during the research.

Table 2: Descriptive statistics of independent variables for Lagos bus stop intersection

Independent Variables	Variable weights	Sample size	Sample mean	Standard deviation	Kurtosis	Standard error of kurtosis	T-test scores
Indiscriminate stopping of vehicles on driveway	A	80	76.0000	12.7884	-0.9765	0.5477	#DIV/0!
	B	20	50.0000	#DIV/0!	#DIV/0!	4.8990	
vehicles parked within drive way	A	50	83.4400	13.7041	-1.4086	0.6928	23.32
	B	53	42.2857	10.4357	-0.3937	1.8516	
Road worthiness	A	56	70.3393	11.4404	-0.3678	0.6547	21.24
	B	41	32.2308	20.6686	-2.3338	1.3587	
Wrong maneuvering	A	81	71.1728	11.7333	-0.5373	0.5443	15.10
	B	19	45.6250	12.3744	8.0000	1.7321	
Driving under drug/alcoholic influences	A	6	74.1667	23.3274	-0.8270	2.0000	7.04
	B	94	44.1563	11.9949	1.0555	0.8660	
Violation of traffic laws	A	73	75.8082	12.4182	-1.2279	0.5734	18.83
	B	27	52.4000	5.3666	4.1573	2.1909	

.

Table 3: Descriptive statistics of independent variables for Amadi-ama intersection

Independent Variables	Variable weights	Sample size	Sample mean	Standard deviation	Kurtosis	Standard error of kurtosis	T-test scores
Indiscriminate stopping of vehicles on driveway	A	27	65.7037037	6.8826136	-0.1565	0.9428	8.60864
	B	72	34.250	16.9941166	2.6611	2.1909	
vehicles parked within drive way	A	22	64.091	6.3539196	1.8284	1.0445	12.85995
	B	76	36.444	16.7489635	-0.6260	1.6330	
Road worthiness	A	53	73.434	17.6073733	6.0226	0.6729	25.98766
	B	47	30.1428571	18.6706563	-1.4885	1.3093	
Wrong maneuvering	A	70	77.78571	10.8986010	-0.4975	0.5855	28.82869
	B	30	37.15385	16.2984976	-0.8945	1.3587	
Driving under drug/alcoholic influences	A	10	74.70000	13.5158343	-0.4381	1.5492	18.91769
	B	90	36.87500	15.5488361	-1.5444	1.0000	
Violation of traffic laws	A	72	78.91667	13.5207196	-1.3473	0.5774	26.33641
	B	27	47.90909	10.8853530	1.2072	1.4771	

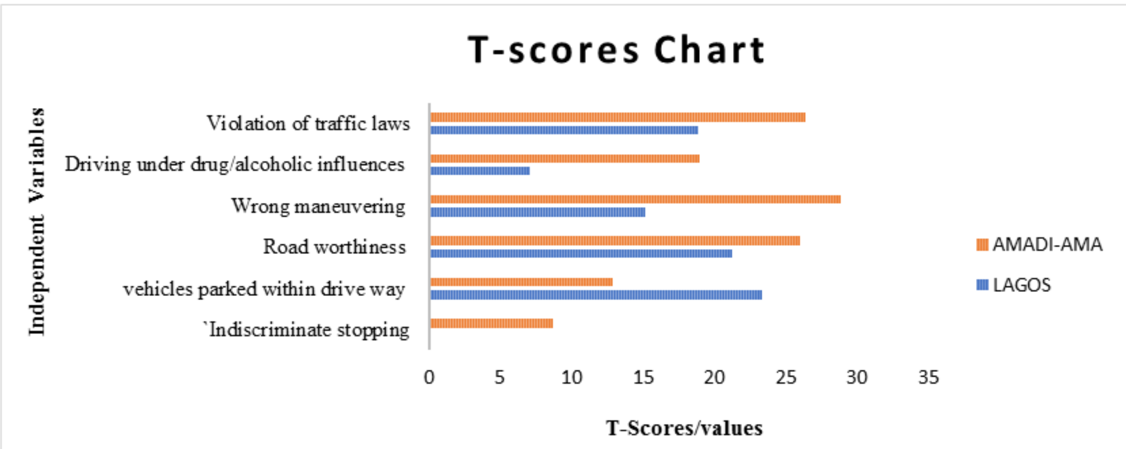

Figure 4: Descriptive T-Test Statistics of Independent Variables for The Selected Intersections

The table above starts with a measurable insight into the responses from respondents as indicated in the sample size column, as to whether these drivers' behaviors are critical, not critical, or not applicable, in the buildup of roadway traffic congestion at the selected intersections studied. Following this, the columns labelled kurtosis, and standard error of kurtosis, are employed to validate the adequacy of the sample sizes of each independent variable in representing the population characteristics. From Table 2, all the independent variables representing various drivers' behavior at the t-test column, are noted to give t-scores of values greater than the standard z-score value of 1.96 for a 5 percent significance level, which is the primary threshold for either accepting or rejecting the null hypothesis, which states that drivers' behavior does not have an effect in the buildup of traffic congestion. From Table 2 below, all the independent variables had t-scores that exceeded the standard threshold of Z=1.96, which invariably supports the rejection of the null hypothesis, as such, affirming the role of drivers' behavior in the buildup of traffic congestion, which also was suggested by Kalašová & Krchová (2011) as a key influence in the formation of congestion**.** Following this, independent variables such as, the Indiscriminate stopping of vehicles on the driveway, vehicles parked on the driveway and road worthiness were observed to possess the highest t-scores amongst others, with t-scores of ∞,23.32 and 21.24 respectively, with the indiscriminate stopping of vehicles on the driveway with t-score of (∞) having the greatest influence in the buildup of roadway traffic congestion at the stated intersection.

Also, Table 3 gives the descriptive statistics for all independent variables considered during the research, done at the Amadi-ama intersection. From the table below, wrong maneuvering with a t-score of 28.82, was noted to have the greatest influence in the buildup of traffic congestion. This however was followed by the violations of traffic rules with a t-score of 26.33 and then road worthiness with a t-score of 25.98. The role of drivers' behavior also was proponed by Kalašová & Krchová (2011) as a key influence in the formation of congestion, Furthermore, fig 4, gives a summary plot of these results

IV. CONCLUSION

From the investigations conducted in accordance to the objectives of this research, the following conclusions were reached;

i. Both intersections accommodate a moderate volume of traffic, notably at the peak periods, with traffic volumes between 2000PCU/hr -2100PCU/hr.

ii. Findings from the research reveals a drastic drag in speed of 7-8km/hr at the bottleneck regions, evidently revealing a state of congestion.

iii. From the investigations conducted, the analysis shows that various driver's behavior such as; Indiscriminate stopping of vehicles on the driveway, vehicles parked on the driveway, road worthiness, wrong maneuvering, and violations of traffic rules, have key negative effects on roadway traffic thereby fostering a state of congestion.

It is however noteworthy to put the following recommendations into considerations,

i. The highlighted drivers' behavior should be considered in the development and implementation stages of localized traffic congestion relief strategies.

ii. Traffic policies should also include severe punishments on offenders as a measure to deter such driver's behavior on the roadway.

iii. The implementation of these policies should be enforced on all social class order, with no prejudice or bias for governmental nor influential persons in the social class hierarchy.

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