



## Influence of Unscheduled Stop and Dwell Time of Minibus Public Transport on Transit Time in Kaduna Metropolis

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### ABSTRACT

*This study investigates the influence of unscheduled stop and dwells time of minibus public transport on transit time in the Kaduna metropolis. The objectives were to determine operating characteristics of minibus public transport (transit time, amount of recurring stops to pick up or to drop off passengers, dwelling time and running time) and to identify the influence of unscheduled stops and dwell time on transit time. The minibus has been one of the modes of public transport in Nigerian cities. Despite its positive impact on urban mobility demand, it is, however, associated with some problems which make its service ineffective. Data were collected on the number of random stops, dwell times per stop, and travel times from route's origin to destination using an in-vehicle observation technique. Three major routes on which minibuses operate were used for the study. Finding from this study revealed that minibus public transport in Kaduna metropolis is characterized by recurring unscheduled random stops and long dwell time. The total number of unscheduled stops throughout the routes studied ranges from 8 to 13 per trip while the cumulative mean dwell time per trip constitutes 8.08% to 34.59% of the transit time leading to increasing in overall passenger's travel time, with attendant delay to the users. A weak correlation exists between the number of unscheduled stops and transit time, indicating less influence on the transit time. However, a strong correlation exists between dwell time during stops and travel time which is an indication of a substantial influence on transit time. Moreover, the number of stops does not influence the transit time significantly; whereas, the dwell time influences the transit time significantly. Furthermore, passengers' transit time is increased drastically due to the long dwell time during unscheduled random stops rather than the number of stops themselves.*

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### INTRODUCTION

Transport is the life wire of urban life. It is one of the factors which determine the form and pattern of socio-economic development of a city. Mobility and accessibility provided by the transport system have been playing a major role in shaping countries, influencing the location of social and economic activity as well as the form and size of cities. Transport also facilitates trade, permitting access to people and resources, and enables greater economies of scale, worldwide (Zuidgest,

2005). Public transport is a collection of modes of transport which are available to the public irrespective of ownership (White, 2002). It includes road-based modes like conventional buses, Para-transit vehicles, human and animal powered vehicles, cycles and walking; rail-based models like heavy rail system, light rail transit, street tramway; and rapid transit systems (Iles, 2005). The main function of the public transport system differs depending on its operating area. In sparsely populated areas, the purpose is to supply



the basic transportation needs, while it in larger cities is to decrease traffic congestion and to improve the environment. On a regional scale the purpose is to create opportunities for education and increase the job market (Hydén *et al.*, 2008).

Efficient urban public transport system has been a challenge for many metropolises worldwide, especially large cities in developing countries. In many parts of Nigeria, minibuses (usually with a capacity of between 10 and 20 passengers) are used for public transport as means of moving relatively large number of people from one place to the other both within and outside cities, because of their size and relatively low price when compared with other means of transport such as taxicabs, tricycles and so on (Muttaka and Yunusa, 2013).

Operational mode of minibuses used for public transport in Kano metropolis particularly their recurring stops and take-ups to pick-up and drop passengers cause a lot of traffic hitches. These affect traffic flow in such a way that other road user's experience uncomfortable drive due to the persistence signals by the minibuses to stop. Thus, making other road users to decelerate or stop for the minibus to stop or take-up before they continue to move. These stops (mostly parking on the road) and take-ups along the road do not allow for free and smooth traffic flow. (Alterkawi, 2006). Those random stops affect the travel time of the bus dramatically and make it very difficult to stick to the original proposed fixed schedule. This leads to unreliable arrival/departure times that were found to be one of the main factors discouraging people from using public transport (Nour, 2009). In addition, other problems are inefficient operations, unreliability of service, poor safety; poor enforcement of rules and regulations guiding public transport operations (Oluwole and Ojekunle 2016). It is most flexible as it satisfies short and long distance mobility demands. It needs less investment on infrastructure, feasible economically to all groups and environmentally friendly system. However, the demand for this service particularly during peak hours is beyond its capacity and the quality of service is poor. Moreover, the general prevailing traffic congestion and inadequate street network constrain the level of service (Oluwole and Ojekunle 2016).

Access and accessibility can be used to measure the performance of public transport system. Access is the opportunity to use system based on proximity and cost. (Geurs and Ritsema, 2001) define accessibility of transport system as the extent to which the system facilitates people's participation in activities. Mobility, proximity and connectivity have been incorporated in accessibility by arguing that it is a function of land use configuration (which gives the idea of proximity), transportation networks and services (issue of connectivity between activities), and system performance, or quality of movement (notion of mobility).

Despite the vital role intra-city buses play in any urban area, their services are frequently insufficient to meet the demand which leads to poor quality of services, overcrowding, environmental pollution among others (Ali, 2010). The buses used for intra-urban passenger services in developed countries are mass transit buses which have the capacity to accommodate twenty or more passengers, depending on the type (Transjakarta, 2011).

In Kaduna metropolis, the situation is different from what obtains in developed nations. Here in Kaduna metropolis, the growing demand for intra-urban bus services is not met by government-owned bus services and this has encouraged the growth of unorganized private small bus operators. Consequently, commuters' legitimate needs are not met because their services are inefficient. The fundamental goal of the Federal Government of Nigeria (2010) is to develop an adequate, safe, environmentally sound, efficient and affordable integrated transport system within the framework of a progressive and competitive market economy. An "adequate transport system" means that available transport infrastructure and services should meet the needs of Nigerians for access to the market, place of work and to basic social services. A "safe transport system" means that all reasonable standards are set and actions taken to prevent accidents and minimize the number of potential victims and the destruction of property. An "environmentally sound transport system" means that reasonable, effective action will be taken to minimize atmospheric and other pollution by the



establishment of appropriate regulatory standards (F.G.N, 2010).

The quality of both living and working environment in Kaduna metropolis are eroded by massive traffic jam, excessive noise, air unfit to breath, overcrowding and difficulties in going to work and journey back home. The quality of transport services is an amalgam of many attributes, such as timeliness, reliability, security, safety, comfort and cleanliness (Mfinanga and Ochieng, 2006). In the past two decades, the city of Kaduna has been experiencing rapid population increase and physical expansion due to influx of immigrants from rural areas to the city. The growth has been accompanied by a substantial expansion of city's boundaries and much higher level of industrial, economic and social activities. These have led to the extension of low income unplanned settlement at the city peripheries and workers from the area exerting increasing pressure on already inadequate transport facilities (Obasanjo and Francis, 2015).

One of the key factors that define accessibility is the travel time between home and activities, or opportunities. Several frameworks have been developed to determine level of service indicators for the effectiveness of public transportation systems (Hassan *et al.*, 2013; Cervero 2013). These systems contain a variety of criteria attributes to evaluate, ranging from cost measures; operational performance and utilization, but virtually always consider travel time as a key indicator.

Travel time was confirmed to be important to the South African travelling public transit. It was indicated as the most common determinant of transport mode choice (32.5%) in the 2013 National Household Travel Survey (Stats, 2014). The cost of travel was indicated as the second largest determinant of mode choice (26.2%). In his book *The Transit Metropolis*, (Cervero 1998) states that the central premise is that transit will only become time-competitive with the car by improving the match between how services are configured and cities are designed. Similar research was carried out by the following authors including their findings and gaps. According to, (Mohamed *et al.*, 2013); Their study concluded that minimizing the unscheduled bus stops will decrease the trip time, and so improve

the service reliability to a large degree. The gap for their research was location. (Hitge and Vanderschuren, 2015) concluded that travelling by public transport takes significantly longer than by private car for the average trip in Cape Town. It then highlights where to focus investment in the public transport system to move towards an integrated, multi-modal system that can compete with the private car, and thereby become attractive to all communities. The gap for their research was location. (Ibrahim and Alhassan, 2020) concluded that the number of stop does not influence the transit time significantly; whereas, the dwell time influences the transit time significantly which implies that increase in passengers' transit time is substantially due to the long dwell time during unscheduled random stop rather than the number of stop itself.

## METHODOLOGY

Correlation analysis was adopted for this research. Correlation Analysis is statistical method that is used to study the strength of a relationship between two variables/datasets, and how strong that relationship may be. Essentially, correlation analysis is used for spotting patterns within datasets. A positive correlation result means that both variables increase in relation to each other, while a negative correlation means that as one variable decreases, the other increases.

This study was conducted in Kaduna. Kaduna is said to be the 3<sup>rd</sup> most populated state in Nigeria. The state is a commercial/civil servant's city in the northern part of Nigeria. It is the third most populous city in Nigeria with an estimated population of over 8,252,366 (National Bureau of Statistic, (2016). This study utilized three major (multi-lane) roads within Kaduna metropolis on which minibus public transport operate. Included among the chosen are; Mando to Kawo road (Route 1), Kawo to Kasuwa road (Route 2), and Kasuwa to Sabon Tasha road (Route 3).

Route 1, 2, and 3 originate from Mando, Kawo, and Kasuwa respectively, while Kawo, Kasuwa and Sabon Tasha final stops. However, Kasuwa serves as common final destination for all the route. Routes 1, 2, and 3, traverse the northern, central, and southern parts of Kaduna metropolis, respectively. The approximate lengths



of Routes 1, 2, and 3 are 8.7 km, 9.1 km, and 14.7 km, respectively. The basis for the choice of these routes out of the many in the metropolis is that they are particularly in good condition and attract substantial number of minibus operators. They also traverse a mixture of land-use areas comprising of business, institutional, residential, and so forth.

Data for this research were generated through field observation. The data were collected using in-vehicle observation technique. In the course of generating the data, three variables were observed by an in-vehicle observer; the travel time (TT) from a route's origin to its final destination, number of stops (NS), and minibus dwell time per stop (DT). Usually, the minibus makes a stop to pick up, drop off or search passengers. To collect the data on the said variables, the observer boarded a randomly selected bus from the study route's origin to its final destination and vice versa.

The travel time was estimated as the interval between the observer boarding time at route's origin and the drop off time at the final destination. The number of stops made between the origin and the final destination of a route were observed by making a record of each stop on a data sheet. The dwell time incurred by the bus during each of the stops is taken as the interval between the moments when the bus made a stop at a particular point and when it took-off from that point. This measurement was made with the aid of a stopwatch by starting timer as soon as the bus stopped; and immediately the bus took-off, the observer stopped the timer. The interval between the two moments was then recorded against that particular stop as the dwell time. Subsequently, the stop watch was reset and the process repeated for further stops along the route.

The data collection on the input variables was conducted on both directions of traffic for the routes used in this work. On each of the study routes, data were collected for three different periods per day; morning, afternoon, and evening for a total duration of seven days. Data for the morning, afternoon, and evening periods were observed from 7 am to 12 noon, 12 noon to 4 pm, and 4 pm to 8 pm, respectively. Observations for a particular period of a day were made within the designated hours. The entire data were collected

on typical week and weekend days during good weather condition.

Other variables deemed important in this study were derived from the field observed data. These include; running time (RT), ratio of dwell time to running time (DT/RT), and ratio of dwell time to travel time (DT/TT). These variables were derived for the purpose of evaluating the characteristics of the minibus public transport system in the study area. Further analyses were performed with a view to evaluate the influence of NS and DT on TT. A correlation analysis was conducted between TT and both NS and DT. This was carried out to examine the degree of correlation between TT and NS, and TT and DT. This analysis would reveal the extent of significance of variability of NS and DT on that of TT. (Ibrahim and Alhassan, 2020)

## RESULTS AND DISCUSSIONS

Results on minibus operating characteristics in the study area and influence of unscheduled random stop and dwell time on transit time are presented and discussed as follows

### *Characteristics of Operating Minibus Public Transport in Kaduna Metropolis*

Minibuses used for public transport in Kaduna metropolis are usually of low capacity, having a seating capacity of 10 passengers. The operating characteristics of the minibuses considered are; transit time, amount of recurring stops to pick up or drop off passengers, and dwell time during the stops. The proportion of the dwell times relative to the bus running and total transit times between route's origin and destinations were also examined. The variations of these variables across the week and weekend days were evaluated. Figures 1 through 3 depict the variations of mean daily travel time (TT), bus dwell time (DT) and number of stop (NS) per trip for three routes 1 to 3 respectively.

By examining Figures 1 to 3 with regard to daily variations of travel time indicates that for most of the mean daily travel times (TT), for route 1, Friday and Saturday recorded highest TT, for route 2 Saturday recorded the highest TT while for route 3 Monday and Wednesday recorded the highest TT. This is not surprising as there are



usually more activities and desire to make trips within the weekdays, such as trips for work, school, hospital, Friday (Jumma'at) Prayer and so

forth. And there are also desires to go to churches at weekend and also to go for recreational activities at weekend.

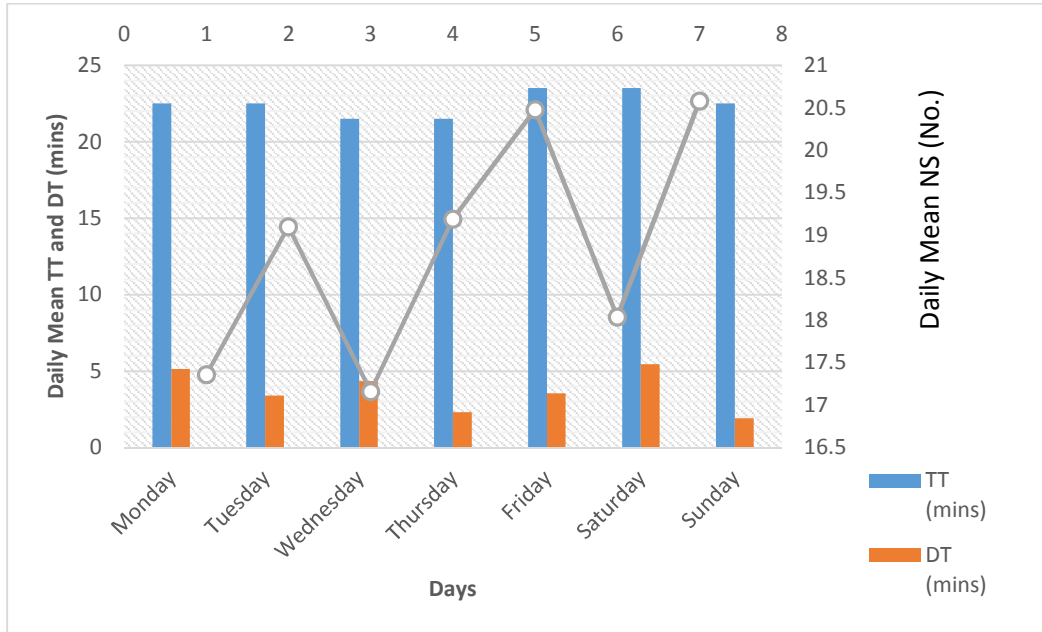
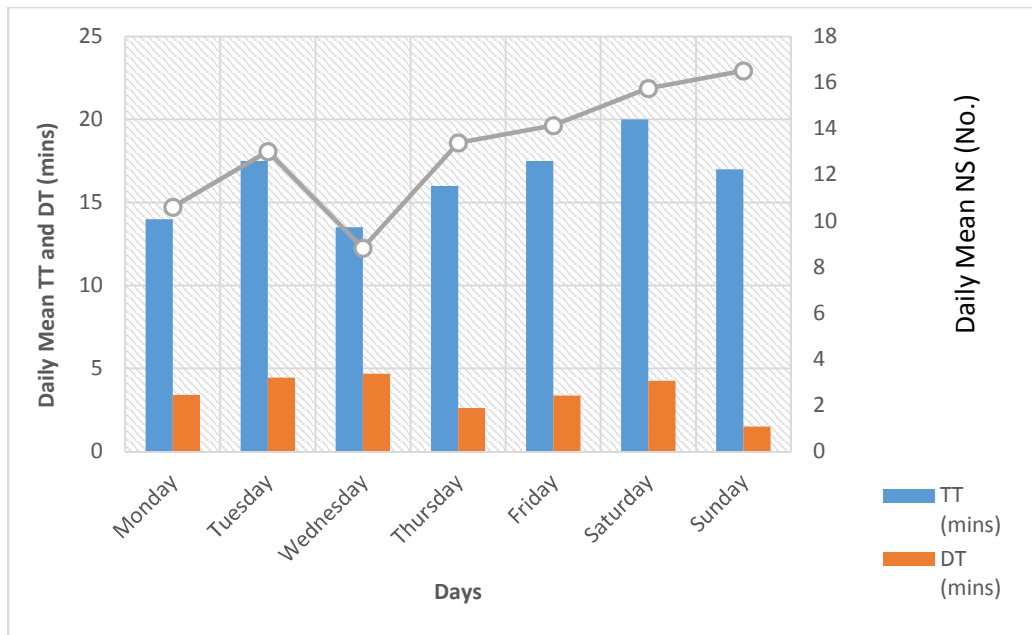
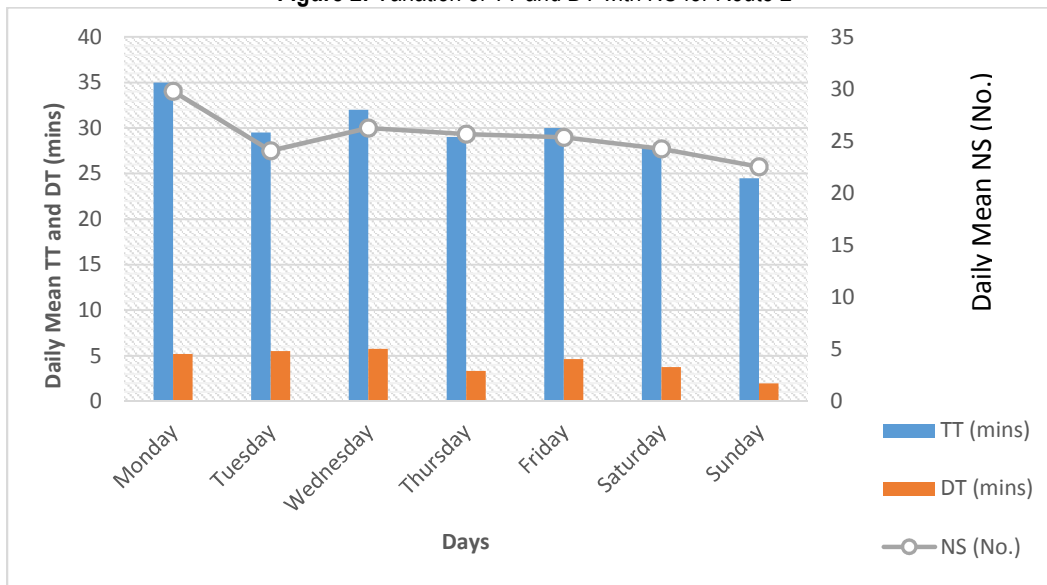


Figure 1: Variation of TT and DT with NS for Route 1



**Figure 2: Variation of TT and DT with NS for Route 2**



**Figure 3: Variation of TT and DT with NS for Route 3**

This finding implies that longer transit times are more associated with longer dwell times during a stop than the stop itself. The trend exhibited seems to be similar for all the three routes studied as depicted in Figures 1 through 3. Thus, the implication of the long dwell times by the minibus operators during the unscheduled stops leads to increase in transit time with attendant negative impacts on the passengers' schedules. It could therefore be said that minibus public transport system within Kaduna metropolis is characterized by frequent unscheduled random stops and long dwell times during the stops.

The dwell time (DT) associated with the minibus unscheduled stops was further evaluated relative to the bus running time (RT) and travel time from route's origin to destination. Two parameters were derived; ratios of dwell time to running time (DT/RT) and dwell time to travel time (DT/TT). This analysis was made in order to examine the extent of proportion of dwell time incurred during a stop to either pick up or drop off a passenger. These were determined based on daily mean estimates for the three routes as presented in Tables 1 to 3.

**Table 1: Ratio of Dwell Time to Running and Travel Times for Route 1**

Days	TT (mins)	DT (mins)	RT (mins)	NS	DT/RT (%)	DT/TT (%)
Monday	22.5	5.14	17.36	10.5	29.61	22.84
Tuesday	22.5	3.40	19.10	9.5	17.80	15.11
Wednesday	21.5	4.35	17.16	9.5	25.35	20.23
Thursday	21.5	2.31	19.19	9.0	12.04	10.74
Friday	23.5	3.56	20.48	10.5	17.38	15.15
Saturday	23.5	5.46	18.04	13	30.27	23.23
Sunday	22.5	1.92	20.58	8.5	9.33	8.53

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**Table 2:** Ratio of Dwell Time to Running and Travel Times for Route 2

Days	TT (mins)	DT (mins)	RT (mins)	NS	DT/RT (%)	DT/TT (%)
Monday	14.0	3.40	10.60	8.5	32.10	24.29
Tuesday	17.5	4.44	13.02	10.0	34.10	25.37
Wednesday	13.5	4.67	8.83	10.5	52.89	34.59
Thursday	16.0	2.62	13.39	8.0	19.57	16.38
Friday	17.5	3.36	14.14	10.5	23.76	19.20
Saturday	20.0	4.25	15.75	10.0	26.98	21.25
Sunday	17.0	1.49	16.51	7.0	9.02	8.76

**Table 3:** Ratio of Dwell Time to Running and Travel Times for Route 3

Days	TT (mins)	DT (mins)	RT (mins)	NS	DT/RT (%)	DT/TT (%)
Monday	35.0	5.21	29.79	12.5	17.49	14.89
Tuesday	29.5	5.53	24.06	12.0	22.98	18.75
Wednesday	32.0	5.76	26.24	13.0	21.95	18.00
Thursday	29.0	3.35	25.65	12.5	13.06	11.55
Friday	30.0	4.65	25.36	12.0	18.34	15.50
Saturday	28.0	3.75	24.25	12.0	15.46	13.39
Sunday	24.5	1.98	22.52	8.0	8.79	8.08

From the results presented in Tables 1 through 3, it can be deduced that based on the ratios of the waiting to the bus running times per trip, the dwell times are in most instances lower than the running times. The maximum ratio of DT/RT obtained is 52.89% which was obtained on a Wednesday of a week day. This finding is a clear indication of high running time when compare with dwelling time which can result to long journey time due to frequent unscheduled stops and dwelling times during the stops. The number of stop ranges from 8 to 13. A similar trend was exhibited by the ratio of dwell to travel times with maximum ratio of DT/TT of 34.59% recorded on same Wednesday of route 2. Across the three routes, the proportion of the dwell times relative to the total transit time ranges from 8.08 to 34.59%. This medium estimate suggests medium dwell times during stops to pick up or drop off passengers and thus results in relative longer transit time to the passengers. These characteristics revealed that the operating system of minibus public transport in Kaduna metropolis is inefficient as passengers are

delayed due to medium dwell times incurred during unscheduled stops.

If the delay experienced by users of minibus public transport in Kaduna metropolis is to be expressed in terms of monetary values, it could amount to a considerable loss. Hence, to safeguard against this, a good policy needs to be put in place to improve the operational characteristics of the minibuses (of which findings from this study could contribute in developing such a policy).

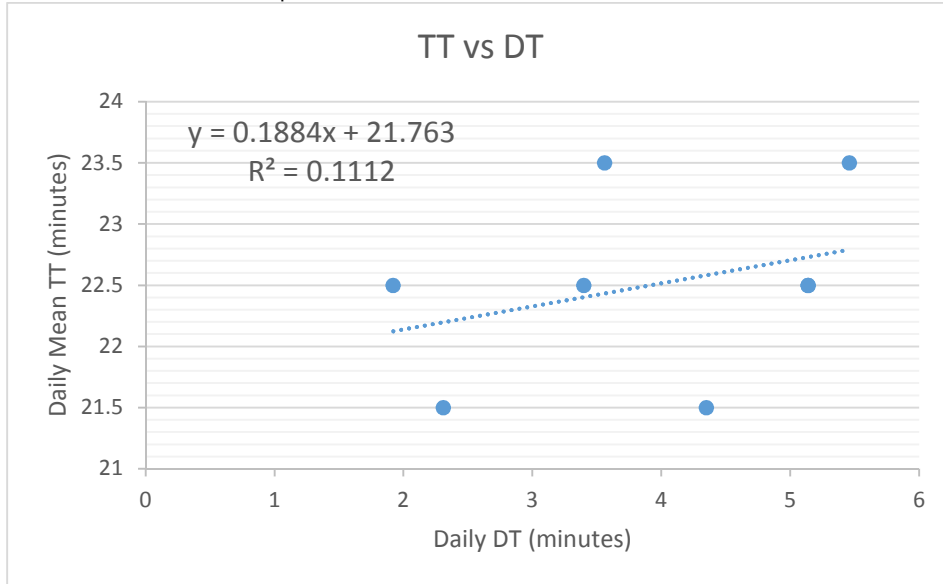
#### ***Influence of Unscheduled Stops and Dwell Time on Transit Time***

In order to assess the effects of minibus unscheduled random stop and dwell time during such stops on transit time, a statistical analysis was performed. Analyses were carried out. Firstly, a correlation analysis between travel time (TT) and both the number of stops (NS) and dwell time (DT) aimed at examining the degree of correlation between TT and NS, and TT and DT. The result of the correlation analysis of TT against DT and TT

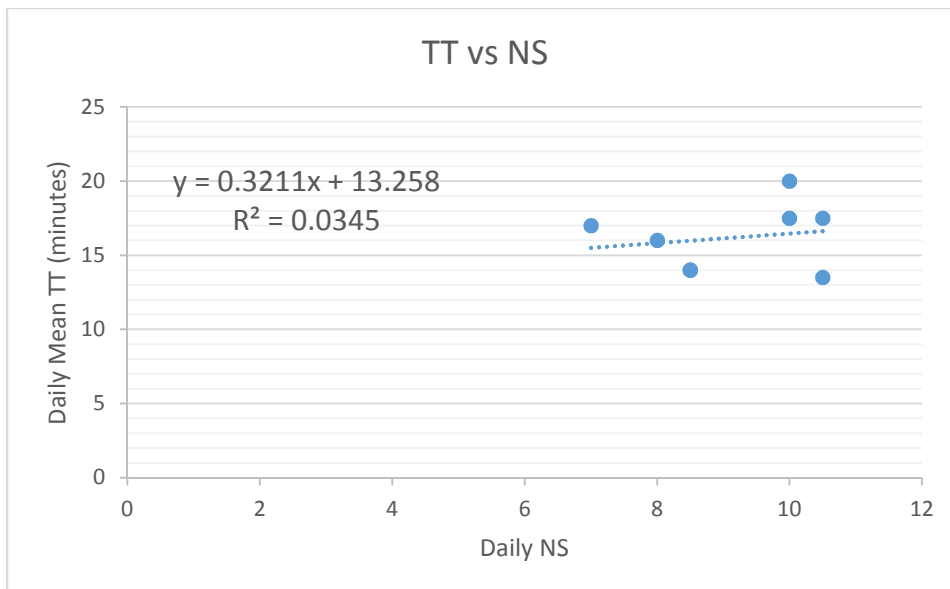


against NS is presented in Figure 4 to 9 and the summary of the coefficient of determination  $R^2$  and coefficient of correlation R is presented in Table 4.

The value of R is determined by finding the square root of  $R^2$ .



**Figure 8:** Correlation between TT and DT for Route 1



**Figure 9:** Correlation between TT and NS for Route 1



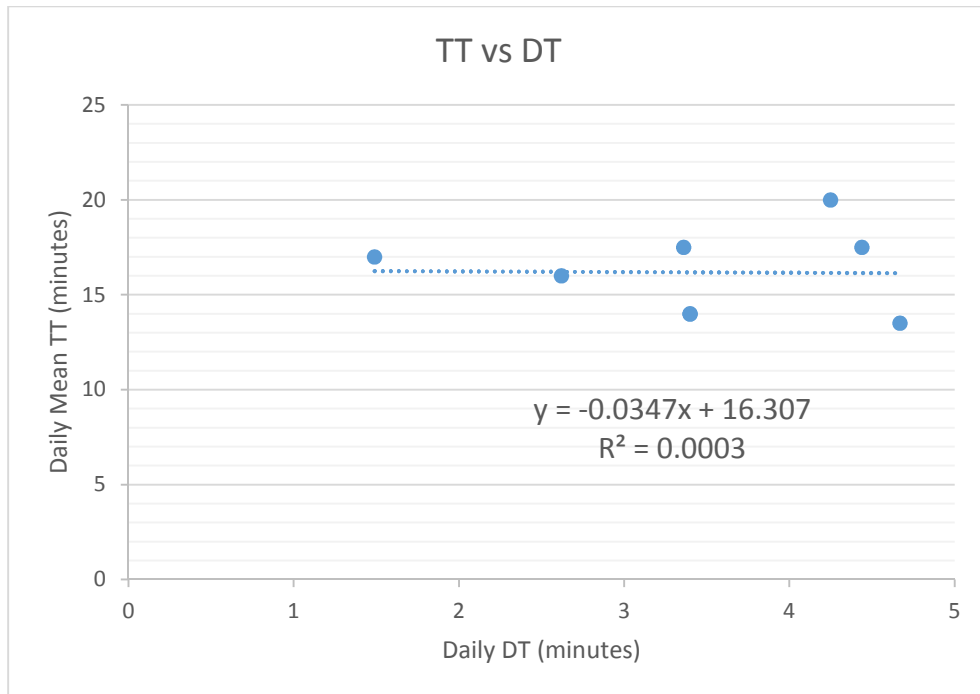


Figure 6: Correlation between TT and DT for Route 2

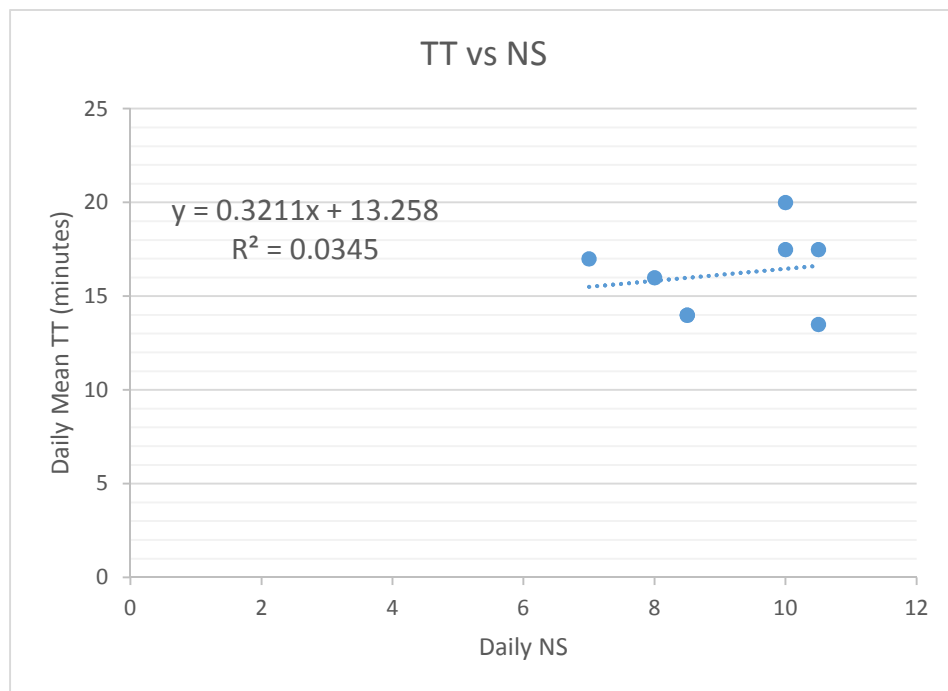


Figure 7: Correlation between TT and NS for Route 2

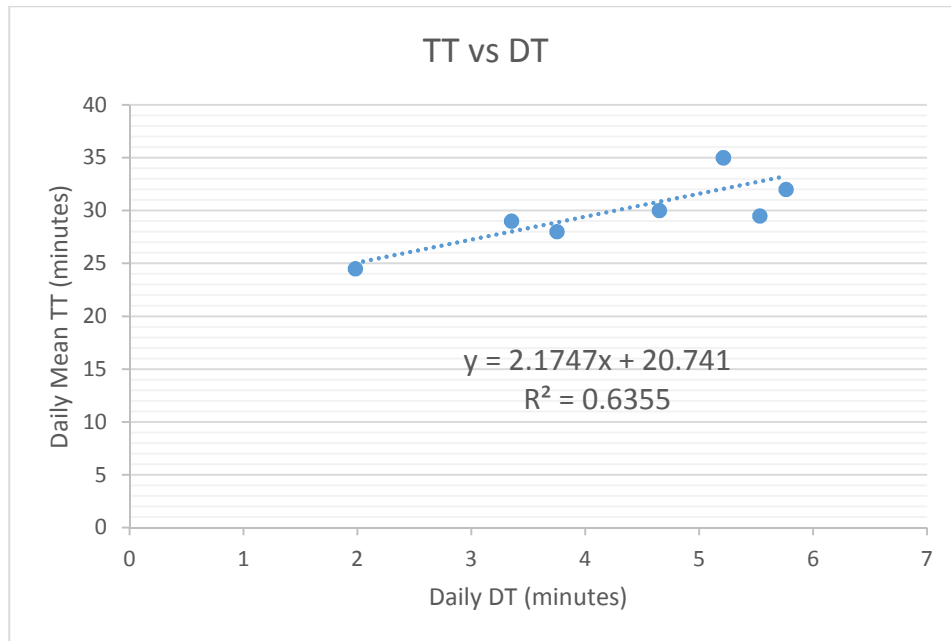


Figure 4: Correlation between TT and DT for Route 3

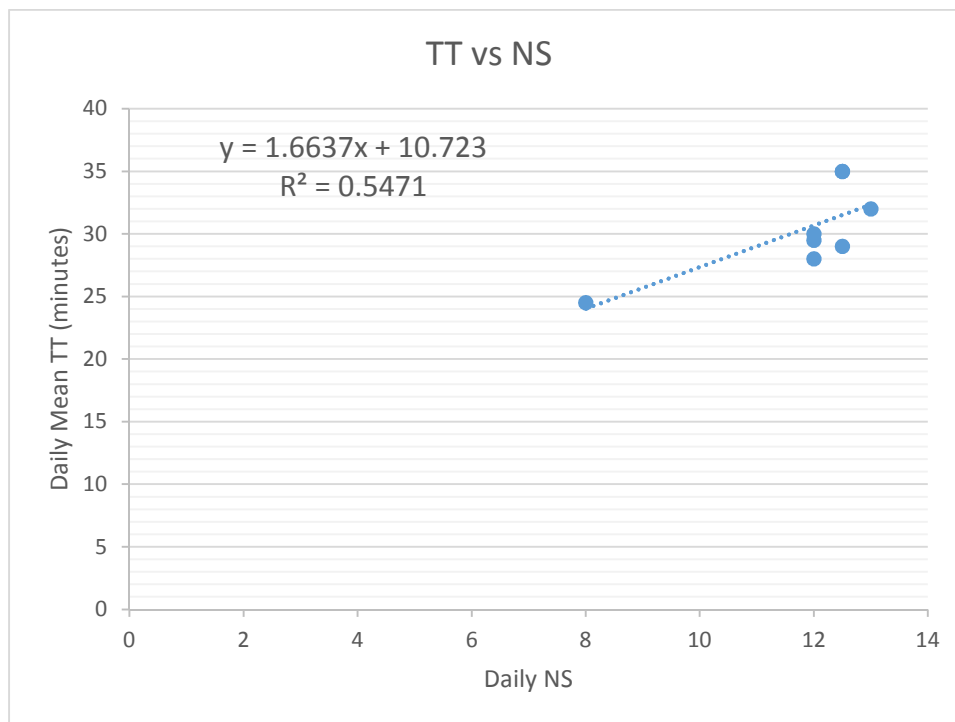


Figure 5: Correlation between TT and NS for Route 3



**Table 4:** Summary of the correlation of TT against DT and NS

Route	Correlation between	Coefficient of determination R <sup>2</sup>	Coefficient of Correlation R	Model Equation
1	TT Vs DT	0.1112	0.3335	TT = 0.1884(DT) + 21.76
	TT Vs NS	0.0345	0.1857	TT = 0.3211(NS) + 13.258
2	TT Vs DT	0.0003	0.0173	TT = -1.0347(DT) + 16.307
	TT Vs NS	0.0345	0.1857	TT = 0.3211(NS) + 13.258
3	TT Vs DT	0.6355	0.7972	TT = 2.1747(DT) + 20.741
	TT Vs NS	0.5471	0.7397	TT = 1.6637(NS) + 10.723

The result presented in Table 4 shows that the correlation between travel time (TT) and number of unscheduled stops (NS) is weak for Route 1 and 2 having a correlation coefficient of 0.0173 and 0.1857 while Route 3 medium having coefficient of 0.7397 relationship. These value implies a weak and medium correlation between NS and TT as correlation coefficients of between 0 and 0.30, 0.31 and 0.59, and 0.60 and 1.00 indicate a weak, medium, and strong correlations, respectively (Ibrahim and Alhassan, 2020). The correlation coefficient value between TT and NS suggests that the number of stops has less influence on transit time. However, the correlation coefficient of 0.740 between TT and DT indicates that a strong correlation exists between these variables. This implies that dwell time incurred during an unscheduled stop has a high influence on transit time. On comparing the influence of NS and DT on TT, the finding indicates that DT has more influence on TT than NS.

## CONCLUSIONS

Based on the results obtained the following conclusions can be drawn:

- (i) The operation of minibus public transport system in Kaduna metropolis is characterized by recurring unscheduled stops and long dwell times. Across the three routes studied, the amount of unscheduled stops ranges from 8 to 13 stops per trip while the cumulative mean dwell time per trip constitutes 8.08 to 34.59% of the passenger's transit time leading to an increase in travel time with attendant delay to passengers.
- (ii) A weak and medium correlation exists between the amount of unscheduled stops and transit time, indicating a less influence on the transit time. However, a strong correlation exists between

dwell time during stops and travel time which is an indication of a substantial influence on transit time.

This implies that increase in passengers' transit time is essentially due the long dwell time during unscheduled stop rather than the amount of stop itself. Hence, to safeguard against this, a good policy needs to be put in place to improve the operational characteristics of the minibuses (of which findings from this study could contribute in developing such a policy)

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