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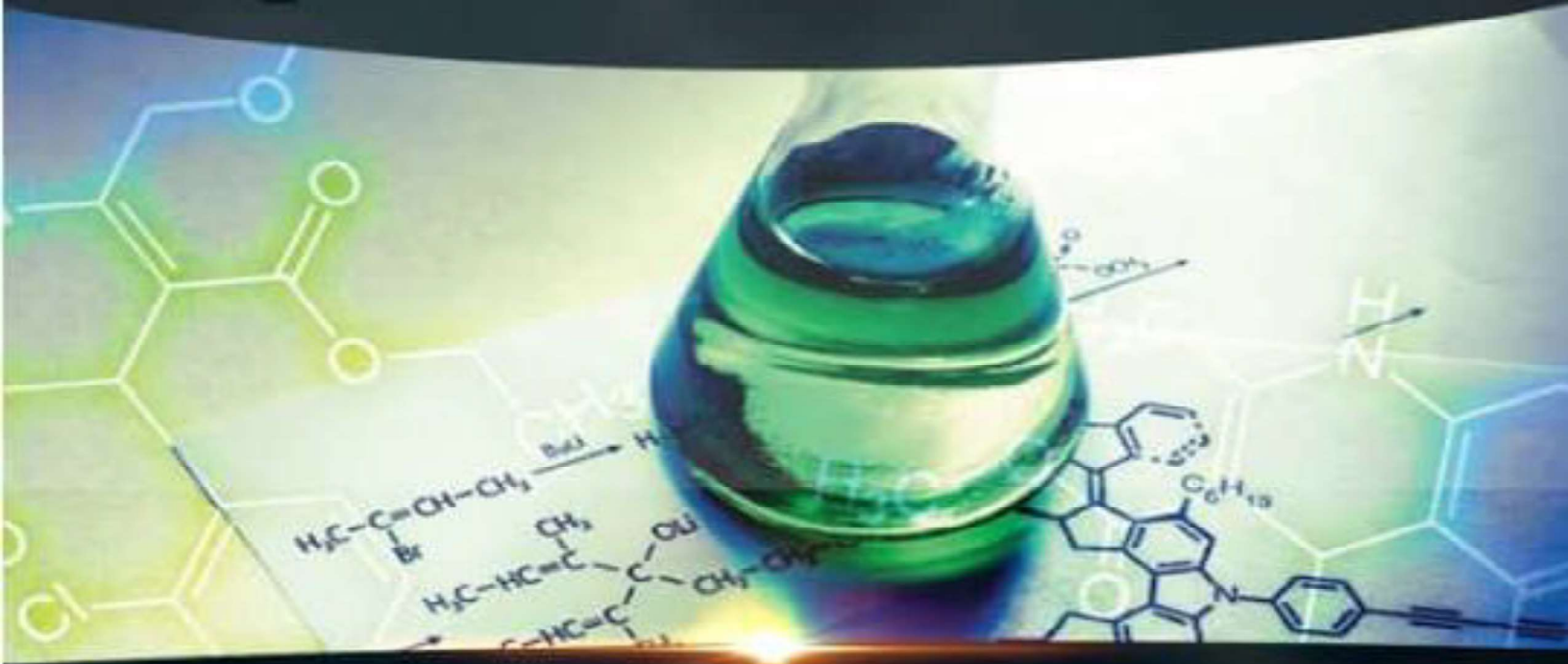

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Spatio-Temporal Variations and Apparent Density of Tsetse Flies (*Glossina* Species) in Selected Old Focal Areas of Niger State, Nigeria

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ABSTRACT

Spatio-Temporal variations and apparent density of tsetse flies (*Glossina* Species) in selected old focal Areas of Niger State was studied. Niger state is an old endemic focus of African trypanosomiasis and the vector tsetse fly (Genus: *Glossina*). Despite the economic and public health impact of the disease in Nigeria, there is no prevailing tsetse record in the various ecological areas of Niger State. Three (3) sites were selected; Bida (Bida LGA), Gbangban (Edati LGA) and Ijah Gwari (Tafa LGA) being old foci of tsetse and trypanosomiasis. Temperature, relative humidity and geo-reference of each sampling point were taken using thermometer, whirling hygrometer and GPS machine while Biconical and Vouvoa tsetse traps were used in catching tsetse flies for 3 days (72 hrs) in each selected site. Catches were removed daily (24 hrs) and identified using standard morphological features and relative abundance recorded. The results were considered significant at P≥0.05. The mean temperature range was 28.48 ± 0.27°C – 32.04 ± 0.42°C while relative humidity was 66.86 ± 1.22% – 74.84 ± 2.19%. The altitude in Ijah Gwari was 494 ± 23.5 m (above sea level), Bida was 109 ± 6.80 m and Gbangban was 93.17 ± 5.18 m. More so, the latitude recorded for Bida was 9.12 ± 0.01°N, Gbangban was 9.14 ± 0.00°N and Ijah Gwari 9.18 ± 0.01°N. A total of 2,251 tsetse flies were caught during the study period. Bida recoded 227 (10.1%), Gbangban 437 (19.4%) and Ijah gwari 1,587 (70.5%). The flies were *Glossina palpalis palpalis* 2,046 (90.9%) and *Glossina tachinoides* 205 (9.1%) both species belong to subgenus *Nemorhina.* A *Glossina* abundance of 2.09 Tsetse/Trap/Day (T/T/D), 4.04 T/T/D and 14.69 T/T/D was recorded for Bida, Gbangban and Ijah Gwari respectively. The difference is attributable to diverse level of vegetation exploitation in study areas.

Key words: Spatio-Temporal, Trypanosomiasis, *Glossina palpalis palpalis* and *Glossina tachinoides, Nemorhina*.

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INTRODUCTION

Tsetse flies (*Glossina* species) are the vectors of trypanosomes which cause trypanosomiasis (sleeping sickness in man and Nagana/Sammore in animals) disease which can be devastating to humans and livestock. This disease occurs mostly in rural areas disturbing agro-pastoral activities in communities (Zeleke, 2011). In 2001, the Pan Africa Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) estimated that tsetse fly infests about 10 million km^2 of the 37 sub-Saharan African countries. Reports indicate a decline in the cases of Human African trypanosomiasis (HAT) to below 10,000 cases per year in the last decade (PATTEC, 2001). However, sleeping sickness remains endemic in several countries, including Nigeria. Animal African trypanosomiasis (AAT) does result to annual losses of about 5 billion US Dollars due to agricultural production inhibitions. The disease poses a big socio-economic burden on sub-Saharan African countries (Shaida *et al*, 2018).

African trypanosomiasis is endemic in Nigeria, and reports indicate an increasing trend of Animal African Trypanosomiasis in Niger State (Adama *et al*, 2010). Records at Niger State Veterinary clinic and pharmacy indicate increase in number of animal trypanosomiasis in the state. There are no concurrent reports of the vectors of the disease in communities of the state where the outbreaks are recorded. During vector control programmes, knowledge of the *Glossina* species is required. Little information is available regarding the spatial variation of the tsetse biotopes and the apparent density of infestation in Niger state. Total eradication has been difficult because of local peculiarities. Though a lot has been done in the past but there are gaps in the available information. This study could, therefore, fill the information gaps to further consolidate the effectiveness of control interventions. The research was aimed at determining spatio-temporal variations and apparent density of tsetse flies in selected old focal areas of Niger State.

METHODOLOGY

Study Area

This study was carried out in three local government areas of Niger State. The State is located in the Southern Guinea Savannah agro-ecological zone in the North central of Nigeria, it lies between latitude 6° 8’ E and longitude 8° 44’ N of the equator. The State experiences distinct dry and wet seasons with an annual rainfall ranging from 1100 mm in the northern part to 1600 mm in the south with a mean of 1350 mm. The rainfall which peaks in September normally begins in April and ends in October. The temperature ranges between 35 and 37.5°C with relative humidity between 40 and 80% in January. The state has 25 LGAs and is bounded with Kwara, Kogi, Kebbi, Zamfara, Kaduna States and FCT and International boundary with republic of Benin along its Western Border. The State covers a land area of about 76,363 km^2 constituting 9% of Nigeria’s total land area (Ahmed *et al*, 2019).

Study Site

Three study sites were selected Ijah Gwari, Bida and Gbangban old foci of tsetse and trypanosomiasis (Nigeria Institute for Trypanosomiasis Research NITR, 1976). Visual inspection revealed suitable habitats along small rivers and stream, Wuye (Ijah Gwari), Muser (Bida) and Etan (Gbangban) in Tafa, Bida and Edati Local Government Areas (LGAs) respectively. The temperature, relative humidity

and geo-reference of each sampling point were taken using thermometers, whirling hygrometer and Garmin e-trex, Global Position System (GPS) machine (Shaida *et al*, 2018). See figure 1.

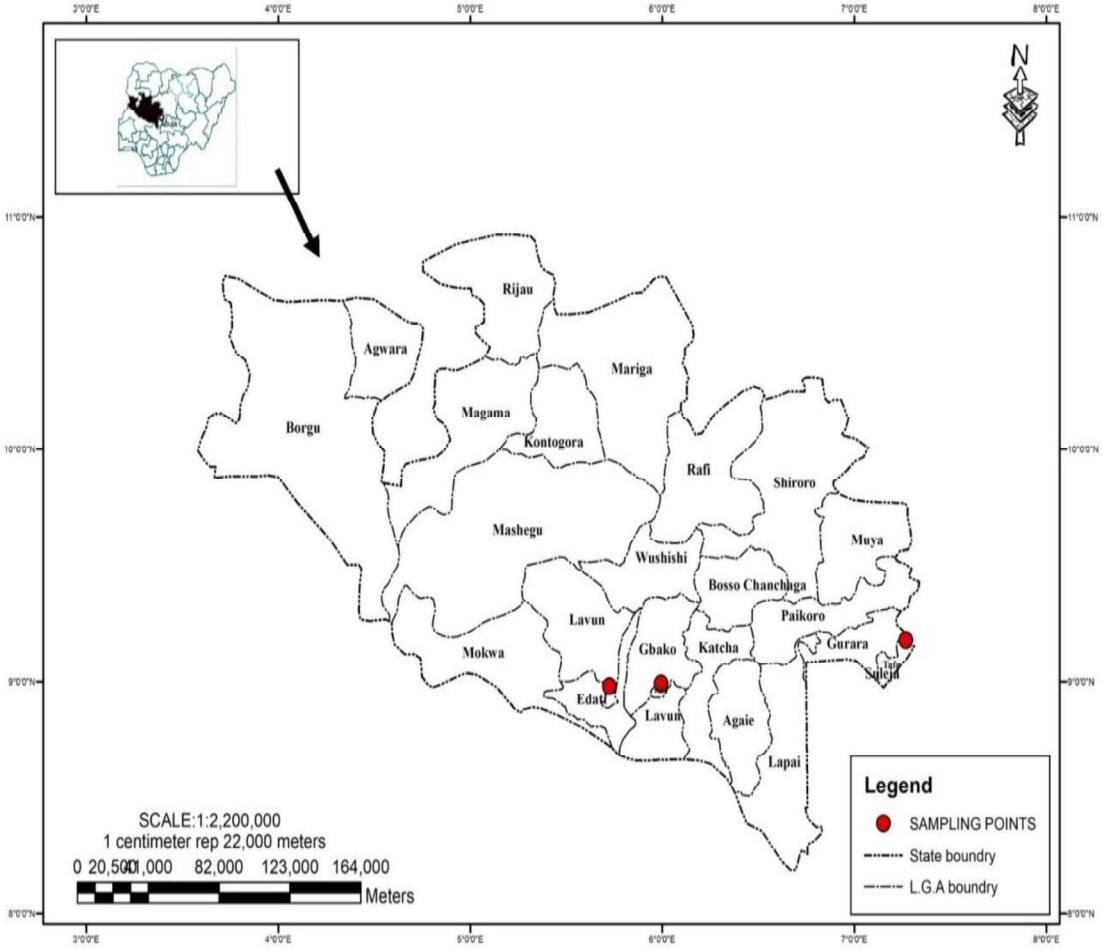

Figure 1: Map of Niger State showing the LGAs and selected study areas.

Entomological Sampling

In each study site, six tsetse traps (Biconical and Vouvoa) were set for three consecutive days (72 hours) in favourable tsetse biotopes (Melachio *et al*, 2011). Flies caught were removed every (24 hours) after which the species, sex and teneral status were identified according to routine morphological criteria (Gibson, 2003). The traps were placed around grazing areas, routes and watering points for animals and suspected larviposition sites (Bocoum *et al*, 2012). The number of tsetse flies caught in each trap was recorded daily and the total for each site was used to estimate the index of apparent abundance (T/T/D) (Adam *et al*, 2012).

Data Analysis

Data collected from all the sites and sampling period were processed as means ± standard deviation (S.D) using excel programme. Mean values of the variables were compared for significance of statistical differences at P≤0.05 level of significance.

RESULT

Physical and Climatic characteristics of *Glossina* habitat in selected areas of Niger State.

The results of physical and climatic parameters of study areas in Niger State are contained in Table 1. The results indicated that there was significant difference (P≤0.05) in the recorded physical and climatic parameters in the three study areas. The temperature ranges from 32.04±0.42°C in Gbangban to 28.48±0.27°C in Ijah Gwari, Relative Humidity ranges from 74.84±2.19 in Ijah Gwari to 66.86±1.22 in Gbangban, respectively. Altitude was significantly highest (P≤0.05) in Ijah Gwari (494±23.5) when compared to other studied areas; Bida (109±6.80 m) and Gbangban (93.17±5.18 m). There was no significant difference (P≥0.05) in Latitude recorded for Bida (9.12±0.01) and Gbangban (9.14±0.00) however, Ijah Gwari recorded a significantly high value of longitude and latitude.

Table 1: Physical and climatic characteristics of *Glossina* habitat in selected areas of Niger State

Study Areas	Temp. (°C) Mean±S.D	R.H Mean±S.D	Altitude (m) Mean±S.D	Latitude (°N) Mean±S.D	Longitude (°E) Mean±S.D
Ijah Gwari	28.48±0.27[a]	74.84±2.19[c]	494±23.15[c]	9.1844±0.01[b]	7.27±0.00[c]
Bida	30.57±0.46[b]	70.56±2.37[b]	109±6.80[b]	9.1221±0.01[a]	6.01±0.00[b]
Gbangban	32.04±0.42[c]	66.86±1.22[a]	93.17±5.19[a]	9.1389±0.00[a]	5.80±0.00[a]

The mean ± standard deviation (S.D) of the temperature (°C), relative humidity (%), altitude Mean value followed by the same super script alphabet in the same column are not significantly different at P=0.05.

***Glossina* abundance in selected areas of Niger State**

The index of apparent abundance (IAA) of *Glossina* is Tsetse per Trap per Day (T/T/D) is presented in Table 3. Ijah Gwari (river Wuye) recorded an overall *Glossina* abundance of 14.69 T/T/D with Bida (river Muser) having 2.09 T/T/D while Gbangban (river Etan) had 4.04 T/T/D. Ijah Gwari (river Wuye) experiences more *Glossina* abundance (22.83 T/T/D and 20.88 T/T/D) during the study in February and March (hot dry season) than any other time in the study area. Moreover, Ijah Gwari (river Wuye) experiences more *Glossina* abundance (22.83 T/T/D in February, 20.88 T/T/D in March, 6.16 T/T/D in June, 14.88T/T/D in July, 12.66T/T/D in August, and 10.72T/T/D in September) than Bida (river Muser) (2.83 T/T/D in February, 1.55 T/T/D in March, 1.55 T/T/D in June, 2.16T/T/D in July, 2.38 T/T/D in August, and 2.11 T/T/D in September) and Gbangban (river Etan) (4.61 T/T/D in February, 3.72 T/T/D in March, 3.38 T/T/D in June, 5.77 T/T/D in July, 3.66 T/T/D in August, and 3.11 T/T/D in September), demonstrating a higher T/T/D values in Ijah Gwari (river Wuye).

Table 3: *Glossina* Relative abundance in selected study areas in Niger State

Month	Location	No. of Traps	No. of Days	No. of *Glossina* caught	Apparent Density (TTD)
February	Ijah Gwari	6	3	411	22.83
	Bida	6	3	51	2.83
	Gbangban	6	3	83	4.61
March	Ijah Gwari	6	3	376	20.88
	Bida	6	3	28	1.55
	Gbangban	6	3	67	3.72
June	Ijah Gwari	6	3	111	6.16
	Bida	6	3	28	1.55
	Gbangban	6	3	61	3.38
July	Ijah Gwari	6	3	268	14.88
	Bida	6	3	39	2.16
	Gbangban	6	3	104	5.77
August	Ijah Gwari	6	3	228	12.66
	Bida	6	3	43	2.38
	Gbangban	6	3	66	3.66
September	Ijah Gwari	6	3	193	10.72
	Bida	6	3	38	2.11
	Gbangban	6	3	56	3.11

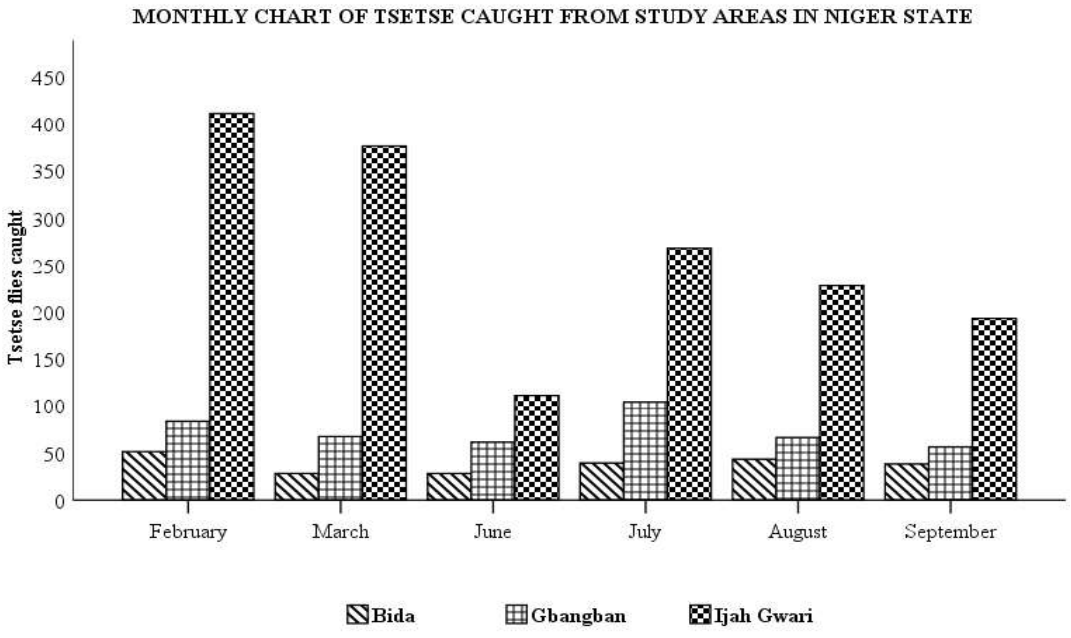

Figure 2: Monthly Chart of Tsetse Fly Caught from Study Areas in Niger State

DISCUSSION

The rivers and type of vegetation encountered in the study areas include Wuye with riverine and fringing forest (Ijah Gwari, Tafa, LGA), Muser with a riverine vegetation (Bida, Bida LGA) and Etan with riverine and woodland Savannah (Gbangban, Edati LGA). All the three rivers flow throughout the year thereby supporting various human and animal activities. The vegetation provides shade and resting site for tsetse fly which is important for survival and larviposition (Leak, 1999).

Human activities were observed to be more at Bida than Gbangban while Ijah Gwari had the least. This may be due to the poor road network to rivers Etan and Wuye which lack vehicle routes, making exploitation difficult (including agriculture practices). This agrees with the findings of Tekle (2010) who reported in a study that, "Man is adjudged the most important animal in the environment of Tsetse fly, people kill them by crushing, modify their environment by various agricultural practices, deliberately destroy the environment, eliminate wild animals and spread poison (insecticide) to kill tsetse directly.

The most exploited of the study areas is Bida where the human settlement and crop farming has interfered with the natural environment. The level of exploitation at Gbangban can be said to be moderate with human settlement 3km away, removal of trees for domestic purposes is quite significant. Ijah-Gwari presents more luxuriant vegetation with two storey forest out layer and human settlement far away, provides ideal tsetse resting and breeding site. The activities of the chain saw operators could lead to reduced insulation due to the removal of big trees which will lead to more sunlight penetration thereby increasing the temperature and reducing the relative humidity as observed and reported by Leak (1999).

Although, the means of temperature and relative humidity recorded in the study areas differed significantly ($P \leq 0.05$), they were found to be within the Tsetse fly tolerable limit. This finding is in agreement with the report of Pagabeleguem *et al* (2016). Generally, under controlled conditions (Laboratory) tsetse does well at temperature near 25^{o}C, departures from this favourable temperature has progressive deleterious effects, culminating in rapid death at 46^{o}C and at sub-zero temperatures (Terblanche *et al*., 2008). The result indicates temperatures at Ijah Gwari more ideal compared to Bida and Gbangban. The relative humidity recorded revealed an inverse relationship with temperature (Lower temperature higher relative humidity) throughout the study period which agrees with the report of Wint and Rodgers (2000). The physical characteristics (Altitude, Longitude and Latitude) of all the study areas were within tsetse distribution limits given by FAO (2004) . Although there is significant difference ($P \leq 0.05$) in the physical characteristics of the study area they all fall in the tsetse distribution limits in Nigeria.

Glossina density recorded from study areas differed significantly ($P \leq 0.05$) and may be attributed to difference in vegetation which is influenced by human activities. Ijah Gwari (river Wuye) with a more dense riverine vegetation and low human activity had a high density. Bida (river Muser) with a sparse riverine vegetation and high human activity while Gbangban (river Etan) with Savannah woodland vegetation and moderate human activity having low densities. This is in agreement with the findings of Bouyer *et al*., (2005), who reported the relationship between plant and human activity and the

distribution of riverine species of *Glossina* which are influenced by the land use land cover.

The study revealed the abundance of 2 species of *Glossina* which belong to the riverine group of flies (*Palpalis* group). This is contrary to the historical records of Glover (1961) who reported abundance of Savannah flies (*Morsitans* group) in the Bida area. Ahmed (2010) reported the abundance of *G*. *palpalis palplis* and *G*. *tachinoides* in 3 streams in Agaie LGA of Niger State which agree with the findings of this study. Tsetse flies have specific ecological requirements that differ between species (Reid *et al.,* 2000). *Palpalis* group flies lives in forests where optimum atmospheric conditions can be maintained. The disturbances of riverine forest at Bida and Gbangban and beyond significantly reduce the suitable habitat of *Glossina* and may lead to the complete disappearance of the species. This may be the reason for the low abundance recorded in Bida and Gbangban. Adam *et al*., (2012) stated that *G*. *tachinoides* can cope with more open vegetation and is less affected by anthropogenic changes of the vegetation. This could be the reason for recording more *G*. *tachinoides* in the two areas (Bida and Gbangban) than Ijah Gwari which is a highland riverine forest reported by Reid *et al.,* (2000) not favourable for *G*. *tachinoides* survival which is known to prefer lowland riverine forest which was encountered at Bida and Gbangban. The abundance of *Glossina* was higher in the dry season in all the study areas compared to the rainy season. Okoh *et al*., (2011) reported lower abundance in the rainy season compared to dry season. Low density of tsetse in wet season correlates with low emergence and vice versa in the dry season.

CONCLUSION

The study revealed spatial and temporal diversity in the tsetse habitat. The temperature and relative humidity obtained were found to be within the tolerable limit of the genus *Glossina* and the variation observed in the study areas could be the effect of difference in vegetation cover. Furthermore, the two species of tsetse fly recorded are important in the transmission of trypanosomiasis in Nigeria.

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Competing Interests

The authors declared they have no competing interests and objection to the publication.

Authors Contributions

OIK conceived and supervised the study. MUB designed, executed the fieldwork, morphologically identified the tsetse flies and drafted the manuscript. SIM, UAC, AKA and YAB carried out data collection, statistical analysis, participated in study design and helped in drafting the manuscript. All authors read and approved the final manuscript

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