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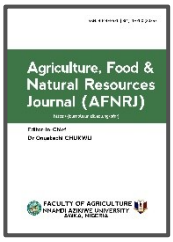

Original Article

Assessment of physicochemical parameters and fish composition of Warwade reservoir, Jigawa State, Nigeria

OPEN ACCESS

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A B S T R A C T

This study investigated the seasonal variations in physicochemical parameters, plankton community structure, and fish species composition of Warwade Reservoir, Nigeria, from May to October. Monthly sampling was conducted to assess water quality variables including temperature, pH, dissolved oxygen (DO), electrical conductivity (EC), nitrate, and phosphate, and fish assemblages. Water samples for the determination of physicochemical parameters were collected at selected sampling points. Some parameters such as water temperature and dissolved oxygen were measured in situ (at the sampling site) using portable water quality meters. Other parameters were analyzed in the laboratory using standard methods, fish samples were collected from the catches of the fishermen and captured fish were identified to species level, counted and recorded, and data were subjected to analysis of variance (ANOVA) to determine monthly variations. Results showed significant monthly variation in temperature, pH, and phosphate concentration ($P< 0.05$), while DO, EC, and nitrate exhibited no significant differences ($P>0.05$). Water quality parameters largely remained within permissible limits, indicating generally good water quality, although dissolved oxygen levels were consistently below the recommended 5 mg/L threshold. A total of nine fish species were recorded, with Oreochromis niloticus, Coptodon zilli, and Sarotherodon galilaeus being the most dominant. Fish abundance varied significantly across months ($P< 0.05$), with peak abundance occurring during August and September, corresponding with increased plankton productivity and favorable hydrological conditions. The study demonstrates that seasonal hydrological dynamics and nutrient availability play critical roles in shaping the ecological structure and productivity of Warwade Reservoir. Continuous monitoring and sustainable fisheries management strategies are recommended to ensure long-term ecosystem health and resource sustainability.

K E Y W O R D S : *Aquatic biodiversity, Freshwater ecosystem, Limnology, Water quality index*

INTRODUCTION

Freshwater reservoirs are important aquatic ecosystems that support diverse biological communities and provide essential resources for human populations. They provide water for domestic use, irrigation, fisheries, and recreation while also supporting biodiversity and ecosystem services. Fish represent one of the most important biological resources in freshwater ecosystems because they contribute significantly to food security, nutrition, and livelihoods in many developing countries (Roy & Saikia, 2023). Monitoring fish communities in reservoirs is therefore important for assessing ecosystem productivity and sustainability (Petriki & Bobori, 2024).

Fish species composition and abundance in aquatic ecosystems are strongly influenced by environmental factors, particularly physicochemical parameters such as water temperature, pH, dissolved oxygen, and electrical conductivity (Berker &

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Doğan, 2023). These parameters determine the suitability of aquatic habitats for different fish species and influence their distribution, growth, and survival. Variations in these physicochemical characteristics can therefore lead to changes in fish diversity, abundance, and community structure within freshwater ecosystems (Akongyuure & Alhassan, 2021).

Several studies have shown that monitoring fish communities together with water quality parameters provides important insights into the ecological status of freshwater environments. For example, physicochemical parameters such as dissolved oxygen, and conductivity have been reported to influence fish occurrence and productivity in reservoirs (Bashir *et al*., 2024). Understanding these relationships is important for evaluating ecosystem health and supporting effective fisheries management strategies.

Environmental changes caused by natural processes or human activities can significantly alter water quality and affect fish populations. Pollution, nutrient enrichment, and increasing anthropogenic activities around reservoirs may disrupt aquatic ecosystems and influence fish diversity and abundance (Asiru *et al*., 2025). Therefore, regular monitoring of both fish species composition and physicochemical parameters is necessary for the sustainable management and conservation of freshwater resources.

Despite the ecological and economic importance of reservoirs, there is limited documented information on the fish species composition and physicochemical characteristics of Warwade Reservoir. Such information is important for understanding the ecological condition of the reservoir and for supporting proper fisheries management. Therefore, this study aims to assess the fish species composition, abundance, and physicochemical parameters of Warwade Reservoir, with the objective of providing information that will contribute to sustainable fisheries management and conservation of aquatic biodiversity.

MATERIALS AND METHOD

Study Area

The study was conducted at Warwade Reservoir which is located on latitude 11° 45'N and longitude 9° .13'E. The study area has a brief wet season, with most of the rainfall falling between May and September, and a prolonged dry season, lasting from October to May, when the climate is dominated by the harmattan winds (IJISRT, 2021).

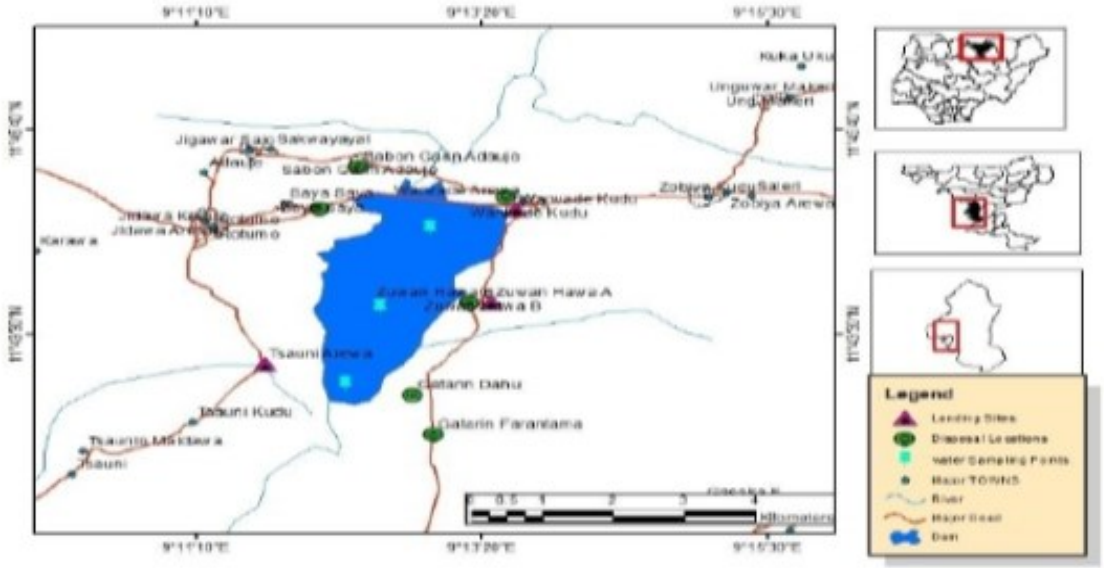

Figure 1: Map of Warwade Reservoir showing the study area. (Source: Miga *et al*., 2025).)

Water Quality Parameters

Determination of Temperature

Water temperature (°C) was measured in situ by directly immersing a calibrated thermometer at a depth of 10 cm below the water surface. After allowing sufficient time for stabilization, the temperature was recorded immediately in the field notebook as described by APHA (2005).

Dissolved Oxygen (DO)

Dissolved oxygen was measured using a portable dissolved oxygen meter model DO9100. The DO probe was immersed 10

cm below the water surface, and readings were recorded after stabilization and expressed in mg/L (APHA, 2005).

Hydrogen Ion Concentration (pH)

The pH of water samples was determined in the laboratory using calibrated pH meter model H198130. Water samples were allowed to reach room. The pH electrode was immersed in the sample solution and readings were recorded after stabilization.

Electrical Conductivity (EC)

Electrical conductivity was determined in the laboratory using a calibrated portable conductivity meter. The probe was immersed in the water sample, and readings were recorded after stabilization. Electrical conductivity was expressed in microsiemens per centimeter (µS/cm).

Phosphate (PO_4)

10ml of water was added to 6 drops of reagent 1 and 2, and shaken until the liquid was evenly distributed. One spoon of heaping measurement (white) was added to reagent 3 and shaken. The colour was compared after 5 minutes (APHA, 2005). Phosphate values were recorded in mg/L.

Nitrate (NO_3)

Nitrate contents of the water were determined directly by adding 6 drops each of reagent 1, 2, 3 and 4, of Aqua test kit to the 10ml of the water and shaken vigorously and compare the colour with the colour chart to determine the actual Nitrate content of the water in mg/L (APHA, 2005).

Sampling and Identification of Fish Species

Fish species were sampled monthly from three sampling sites namely: Warwade kudu, Zuwan hawa and Tsauni arewa for the period of six months (May to October, 2025). Fish samples were collected from the catches of fishermen in the field and local names were obtained. The fishes were identified, sorted into species and family using "Field guide to Nigerian Fresh Water Fishes" by Olaosebikan and Raji (2018).

Statistical Analysis

One-way analysis of variance (ANOVA) was used to compare the means of various parameters between months. Duncan Multiple Range Test was used to separate the means. Significant level was taken as $P \leq 0.05$. All the analyses were done using IBM SPSS Statistical package version 23.

RESULTS AND DISCUSSION

Results

Physicochemical parameters

- ***Temperature***

The monthly mean temperature of the reservoir is presented in Table 1. Water temperature varied significantly ($P<0.05$) across months, with the highest mean value recorded in May (32.7±0.36°C) and the lowest in September (27.8±0.26°C). A general decline in temperature was observed from May to September, followed by a slight increase in October.

- ***Hydrogen ion concentration (pH)***

The mean monthly pH of the reservoir is presented in Table 1. The pH value ranged between 6.4 ± 0.92 and 8.0 ± 0.23. The highest pH values recorded were 8.0 and 7.9 during the month of September and October respectively while the lowest values recorded were 6.4 and 6.7 during the month of June and May respectively.

- ***Dissolved oxygen (DO)***

The mean monthly variation of dissolved oxygen is presented in Table 1. Dissolved oxygen (DO) values ranged from 4.0±0.92 to 4.8±0.31 mg/L, with no significant differences observed among months ($P>0.05$). DO levels were generally below the recommended standard of 5 mg/L, indicating moderate oxygen stress conditions.

- ***Electrical Conductivity (EC)***

The mean monthly variation of EC is as presented in Table 1. Electrical conductivity (EC) values showed no significant monthly variation ($P>0.05$), ranging between 0.16±0.55 and 0.22±0.11 µS/cm

- ***Nitrate (NO_3^-)***

Mean monthly variation of nitrate is presented in Table 1. The values ranged from 3.5± 0.66 mg/L to 4.9 ± 0.42 mg/L. The highest values recorded were 4.9 and 4.7 mg/L in the month of September and August respectively while the lowest value recorded was 3.5 mg/L in the month of May.

- ***Phosphate (PO_4^{3-})***

Mean monthly variation of phosphate is presented in Table 1. The values ranged from 0.11± 0.04 mg/L to 0.24 ± 0.01 mg/L. The highest value recorded was 0.24 mg/L in the month of September while the lowest value recorded was 0.11 mg/L in the month of June.

Table 1: Physicochemical parameters of Warwade reservoir

Para/Month	Temp (^{O}C)	pH	DO (mg/L)	EC (uS/cm)	NO_3^- (mg/L)	PO_4^{3-} (mg/L)
May	32.7±0.36^{a}	6.7±0.44^{c}	4.1±0.25^{a}	0.21±0.01^{a}	3.5±0.66^{b}	0.13±0.05^{b}
June	30.9±0.59^{b}	6.4±0.92^{c}	4.2±0.21^{a}	0.22±0.11^{a}	3.9±0.67^{ab}	0.11±0.04^{b}
July	27.9±0.12^{d}	7.1±0.76^{b}	4.0±0.92^{a}	0.16±0.55^{a}	4.4±0.78^{ab}	0.18±0.04^{a}
August	28.8±0.50^{c}	7.2±0.80^{b}	4.8±0.31^{a}	0.20±0.06^{a}	4.7±0.55^{a}	0.21±0.04^{a}
September	27.8±0.26^{d}	8.0±0.23^{a}	4.2±0.95^{a}	0.19±0.06^{a}	4.9±0.42^{a}	0.24±0.01^{a}
October	28.6±0.26^{c}	7.9±0.50^{a}	4.1±1.07^{a}	0.18±0.06^{a}	4.5±0.29^{ab}	0.19±0.05^{a}
P-value	0.0001	0.058	0.7760	0.068	0.080	0.023
FAO	20-30oC	6.5-8.5	>5mg/L	1000 uS/cm	<5 mg/L	<2 mg/L

Mean values with same superscripts in the same column are not significantly different (P >0.05), Key: pH= hydrogen ion concentration, EC = electrical conductivity Temp = temperature, DO =dissolved oxygen, NO_3^-= nitrate, PO_4^{3-} = phosphate.

Fish species identified

The result of fish species identified in Warwade reservoir is shown in Table 2. The species encountered belong to seven families, Family Cichlidae which has the highest number of species represented by *Oreochromis niloticus, Sarotherodon galilaeus* and *Coptodon zilli*. Other families were represented by one species each. Family Alestidae was represented by *Brycinus nurse*, Family Bagridae was represented by *Bagrus bajad*. Family Claroteidae was represented by *Auchenoglanis occidentalis*, Family Claridae was represented by *Clarias gariepinus.* Family Protopteridae was represented by *Protopterus annectens* and Family Arapamidae was represented by *Heterotis niloticus.*

Table 2: Fish species identified in Warwade Reservoir.

Family	Species	Local name	English name
Alestidae	*Brycinus nurse*	Kawara	Nurse Tetra
Arapamidae	*Heterotis niloticus*	Bargi	African arowana
Bagridae	*Bagrus bajad*	Masco/Ragon ruwa	Silver catfish
Claridae	*Clarias gariepinus*	Tarwada	African catfish
Claroteidae	*Auchenoglanis occidentalis*	Buro	Giraffe catfish
Cichlidae	*Oreochromis niloticus*	Karfasa/kanya	Nile tilapia
	Sarotherodon galilaeus	Farar wala	Mango tilapia
	Coptodon zilli	Jan tanko	Redbelly tilapia
Protopteridae	*Protopterus annectens*	Gaiwa	West African lung fish

Monthly mean distribution of fish species in Warwade Reservoir

Table 3 presents the monthly mean distribution of fish species in Warwade Reservoir from May to October. A total of nine fish species were recorded, showing significant monthly variations in abundance ($p < 0.05$). *Clarias gariepinus* exhibited a progressive increase from May (0.66±1.15) to a peak in September (134.00±83.86), followed by a sharp decline in October (9.00±15.59). *Bagrus bayad* recorded its highest abundance in September (40.33±11.06) and lowest in July (0.66±1.15). *Heterotis niloticus* showed moderate fluctuations, peaking in September (11.33±8.62) and reaching its lowest abundance in October (2.66±2.52). *Oreochromis niloticus* dominated the catch composition throughout the study, with the highest abundance recorded in July (504.33±161.87) and the lowest in August (111.66±122.89). *Brycinus nurse* showed marked seasonal variation, attaining peak abundance in September (300.33±277.79) and minimum abundance in July (21.00±25.24). *Coptodon zilli* peaked in August (431.66±381.12) and showed the lowest abundance in May (53.00±23.26).

Sarotherodon galilaeus recorded its highest abundance in September (222.66±230.84) and the lowest in June (56.66±14.57). *Protopterus annectens* and *Auchenoglanis occidentalis* were absent between May and July but appeared during August and September, with peak abundances in September (24.66±25.01 and 14.00±18.52, respectively).

Table 3: Monthly mean distribution of fish species in Warwade Reservoir

Fish species	May	June	July	August	September	October
Clarias gariepinus	0.66±1.15^{f}	5.33±5.51^{e}	35.66±32.33^{c}	49.00±65.96^{b}	134.00±83.86^{a}	9.00±15.59^{d}
Bagrus bayad	3.66±3.79^{d}	3.66±4.04^{d}	0.66±1.15^{e}	18.66±28.94^{b}	40.33±11.06^{a}	4.33±5.13^{c}
Heterotis niloticus	3.66±3.51^{e}	9.00±9.54^{b}	4.00±6.93^{d}	8.33±7.64^{c}	11.33±8.62^{a}	2.66±2.52^{f}
Oreochromis niloticus	339.33±105.81^{b}	257.66±74.38^{e}	504.33±161.87^{a}	111.66±122.89^{c}	261.00±96.14^{d}	284.66±120.44^{c}
Brycinus nurse	137.66±58.73^{e}	246.66±175.05^{b}	21.00±25.24^{a}	229.66±309.78^{c}	300.33±277.79^{a}	152.66±61.44^{d}
Coptodon zilli	53.00±23.26^{f}	90.00±18.25^{e}	315.33±254.34^{b}	431.66±381.12^{a}	174.66±49.57^{d}	199.00±103.76^{c}
Sarotherodon galilaeus	80.00±21.93^{e}	56.66±14.57^{f}	261.33±166.52^{a}	189.33±115.56^{c}	222.66±230.84^{b}	166.33±78.45^{d}
Protopterus annectens	0.00±0.00^{c}	0.00±0.00^{c}	0.00±0.00^{c}	19.00±32.91^{b}	24.66±25.01^{a}	0.00±0.00^{c}
Auchenoglanis occidentalis	0.00±0.00^{c}	0.00±0.00^{c}	0.00±0.00^{c}	5.66±9.81^{b}	14.00±18.52^{a}	0.33±0.58^{c}

Discussion

Physicochemical parameters

The significant variations of the physicochemical parameters of Warwade reservoir were influenced by different environmental conditions. Aquatic organisms depend on certain temperature range for optimal growth (APHA, 1999). In this study, Water temperature ranged from 27.8°C (September) to 32.7°C (May), showing a distinct seasonal pattern. The high temperature in May corresponds to the peak of the dry season, as high ambient air temperatures and reduced cloud cover promote heating of surface waters through increased solar radiation input to the water body (O'Reilly *et al*., 2015). Conversely, the lowest temperature recorded in September coincides with the rainy season, when increased rainfall, cloud cover, and inflow of cooler runoff reduce water temperature. This shown that the temperature range in Warwade reservoir is suitable for fish growth. Recent research shows that dissolved oxygen levels in freshwater systems are not constant but fluctuate significantly over time, largely influenced by water temperature, depth, physical mixing (such as wind), and biological processes like degradation and respiration (Xie *et al.,* 2025). In this study the dissolved oxygen ranged from 4.0–4.8 mg/L, which is adequate but on the lower threshold for sustaining sensitive fish species. The lowest DO in July may be linked to increased turbidity and organic load during early rainfall periods, which increases microbial respiration and reduces oxygen availability. The slightly higher DO in August corresponds with mixing of the water column due to rainfall and wind action (Al-khadher *et al*.,2025). Dissolved oxygen recorded in this study was low in comparison with WHO (2003) and FEPA (2003) who recommended 5 mg/L and 6.29 mg/L for drinking water. In fish, Gietema (1992) reported that dissolved oxygen above 4.5 mg/l induce good growth rate and favorable feed conversion, while levels of 2-4.5 mg/l induce loss of appetite and unfavorable feed conversion. Gietema, (1992) also reported that levels less than 2.0 mg/L were reported harmful leading to gasping, sub-lethal and lethal effects. pH values recorded in this study ranged from 6.4 to 8.0 which fell within the acceptable water quality standards for both aquaculture and water supply, as recommended by Philminaq (2006) and Francis-Floyd *et al*. (2024), indicating a generally healthy aquatic environment. The highest pH value in September may be associated with increased photosynthetic activity during the rainy season, as elevated phytoplankton abundance tends to reduce carbon dioxide concentrations through photosynthetic activity (Rasilo *et al.,*2020), thereby increasing pH level. The lowest pH in June might reflect organic matter decomposition or inflow of slightly acidic runoff. The pH values recorded in this study were slightly similar to the results of Usman *et al*., (2017) in Ajiwa reservoir who recorded pH range of 6.67 – 7.34.

Variation in conductivity is an indication of the extent to which the lake circulates nutrients, especially in a nutrient rich lake. The conductivity values in this study varied from 0.16 ± 0.55µS/cm to 0.22 ± 0.11 µS/cm which indicated very low ionic concentration. The slight increase observed in June may reflect dissolved ions entering the reservoir from early runoff, while the lowest conductivity in July may corresponds with dilution by heavy rainfall. Conductivity values in the reservoir were low in comparison to the 200-600 µS/cm maximum acceptable limits in drinking water (WHO, 2004). Recent research shows that water with relatively low electrical conductivity, when within standard criteria can be considered suitable for sustainable aquaculture practices (Tennyson, 2025). Therefore, it is perceptible that the water of the study area as far as conductivity is concerned, is suitable for aquaculture, drinking and other domestic uses.

Nitrate is the major form of dissolved inorganic nitrogen utilized by phytoplankton for growth and primary production in aquatic ecosystems (Zilius *et al.,* 2024), In this study nitrate values ranged from 3.5 to 4.9 mg/L which was below the

recommended standard by (WHO 2003). The observed highest nitrate levels in September may be attributed to increased leaching of agricultural fertilizers from surrounding catchments during peak rainfall. Whereas the lowest value in May corresponds with the late dry season characterized by minimal external nutrient input and enhanced biological uptake (Assa *et al*., 2024).

Phosphate and nitrate levels are a measure of level of eutrophication of a given lake (Kolo *et al.,* 2010). Phosphate values of this study ranged from 0.11± 0.04 mg/L to 0.24 ± 0.01 mg/L. The highest value recorded was 0.24 mg/L in the month of September which was comparable with the 0.26 mg/L (WHO, 2003) but low in comparison to FEPA, (2003) maximum acceptable limit of 5 mg/L. This pattern indicates a distinct seasonal influence on phosphate availability within the reservoir.

Fish species composition

The dominance of the family Cichlidae may be due to available plankton and their copious reproductive pattern and good parental care. The high abundance of *Oreochromis niloticus* in July coincides with peak phytoplankton availability, particularly Chlorophyceae and Cyanophyceae, which constitute major food sources for tilapiine species. Dominance of cichlidae family is in consistent with other studies on Nigerian reservoirs, which report cichlids as the most dominant species (Ataguba *et al*., 2014) (Agali *et al*., 2016). This finding is similar with the work of (Oyewo, 2015) that identified 12 species from 6 families at Dogon ruwa water body with cichlids being dominant species. *Clarias gariepinus* and *Bagrus bayad*, both benthic and predatory species, showed progressive increases toward September, likely reflecting improved feeding opportunities from increased zooplankton and juvenile fish abundance. Their decline in October may be attributed to post-flood habitat contraction and increased fishing pressure. The peak abundance of most species in September may be linked to increased water volume, expanded habitat availability, and enhanced food resources during peak rainy season. The species composition observed in this study is lower than the findings of (Adaka, *et al.,* 2016) who reported 32 species from 18 families from Oguta lake, also lower than that of (Ja′afaru & Abubakar, 2015) who reported 26 species from 14 families at Dadin-kowa dam. However, it is higher than the findings of Ahmad *et al*, (2014), who reported only 8 species from 4 families in Katsina State water body.

CONCLUSION AND RECOMMENDATIONS

The physicochemical characteristics of Warwade reservoir indicated a relatively stable aquatic environment capable of supporting freshwater organisms, including fish populations. Variations in temperature, pH and phosphate reflect the influence of climatic conditions on the reservoir. The stability of dissolved oxygen, electrical conductivity, and nitrate levels suggests minimal environmental stress and limited nutrient enrichment. These conditions are favorable for maintaining fish abundance and overall ecological balance within the reservoir.

Species composition of warwade reservoir, nine (9) species belonging to seven (7) families were identified during the study period, highlighting a clear dominance of cichlid species and low abundance of *Auchenoglanis occidentalis.* The observed species composition reflects the combined influence of environmental conditions, habitat characteristics and fishing practices within the reservoir. Cichlids dominate due to their broad ecological tolerance, high reproductive nature and flexible feeding, which enable them exploit to shallow nutrient-rich and fluctuating water quality condition present in warwade. The least abundance of *Auchenoglanis occidentalis* may be due to low dissolved oxygen of the reservoir as bottom-dwelling species are vulnerable to low dissolved oxygen and can be removed as bycatch which can disproportionately remove adults and reduce recruitment capacity.

Based on the findings of this study, the following recommendations were made that;

i. Regular monitoring of physicochemical parameters, particularly temperature and dissolved oxygen, be carried out to detect early signs of environmental change that may affect fish abundance.
ii. Continuous monitoring of phytoplankton composition and abundance to detect early signs of cyanobacterial bloom formation.
iii. Regulation of fishing effort, gear type, and mesh size is recommended to prevent overexploitation of fish species.
iv. Additional research on fish biodiversity and ecosystem health will provide deeper insights needed for effective management planning.

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Authors′ Contributions

M.M managed data collection, interpretation of data and writing of manuscript. M.A.H managed the literature searches. I.Y.A & M.W managed the development of methodology and data analysis. All authors read and approved the final manuscript.

Ethical Statement

Not applicable.

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