

Original Article

## Influence of Water Physicochemical Properties on the Distribution of Schistosomiasis Vectors in Selected Communities of Jos, Nigeria

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### Abstract

**Background:** Schistosomiasis is a neglected tropical disease caused by parasitic worms. It remains a significant public health concern in Nigeria, particularly in communities with limited access to clean water and sanitation. This study investigated the influence of water physicochemical properties on the distribution of Schistosomiasis vectors in three selected communities – Jenta Adamu, Tudun Wada and Student Village Russau, within Jos North Local Government Area, Plateau State, Nigeria.

**Objectives:** The study assessed the physicochemical parameters of water bodies and identified the distribution of schistosomiasis vectors in the study area.

**Methods:** A cross-sectional research design was employed, with water and snail samples collected from selected freshwater bodies. Chi square and ANOVA were tested at  $p < 0.05$  level of significance to determine association with variables.

**Results:** The results recorded variations in water quality across different parameters, with Jenta Adamu; temperature, pH, COD, DO and CO<sub>2</sub> (26.80±0.42 °C, 7.80±0.05, 578.6±6.00 mg/L, 8.04 mg/L and 13.4±0.75 mg/L). While Tudun Wada recorded temperature, pH, salinity and DO (21.76±0.21 °C, 6.94±0.07 mg/L, 175.4±2.09 mg/L and 5.56±0.63 mg/L), with Student Village Russau having temperature, pH, salinity and DO (29.12±0.08 °C, 7.18±0.09 mg/L, 277.8±4.47 mg/L and 5.52±0.71 mg/L). Two snail species were identified, *Bulinus globosus* (53.41%) and *Biomphalaria pfeifferi* (46.59%). *Bulinus globosus* dominated in Jenta Adamu (63.83%), while *Biomphalaria pfeifferi* was more prevalent in Student Village Russau, (60.98%).

**Conclusion:** The study concludes that the coexistence of both snail species in the study area poses a dual risk for urogenital and intestinal schistosomiasis. These findings contribute to understanding the ecological dynamics of schistosomiasis vectors and inform strategies for disease control in endemic regions.

**Keywords:** Distribution, Influence, Physicochemical, Schistosomiasis and Water

## Introduction

Schistosomiasis, also known as bilharzia, is classified as a neglected tropical disease, (1,2,3). It is an acute and chronic disease caused by parasitic worms (4,5) mainly prevalent in poor and developing countries without access to safe drinking water, adequate sanitation, poor hygiene practices and limited health care facilities (4,5,6,7). The disease is most commonly found in tropical and subtropical Africa, Middle East, Asia and South America (5,8). In tropical countries, Schistosomiasis is second only to malaria as a parasitic disease of socio economic and public health importance (3,9,10). There are 2 major forms of Schistosomiasis; intestinal and urogenital Schistosomiasis parasites (5,11). The *Biomphalaria* species serves as the intermediate host for *S. mansoni*, *S. japonicum*, *S. haematobium* and the 3 minor species *S. mekongi*, *S. guineensis*, *S. intercalatum*, which are regionally specific to parts of Africa, Asia, and the Americas (5).

Schistosomiasis cases occur in about 258 million people worldwide (12,13). The most affected region is the Sub-Saharan African countries with about 90% of the world's total cases who require treatment for Schistosomiasis (3,5,6,13). According to report by WHO current estimates, 78 countries and territories remain endemic and nearly 800 million people are exposed to the diseases causing approximately 24,000 deaths and at least 2.5 million disability-adjusted life years (DALYs) (14,15). About 251.4 million people required preventive treatment in 2021, out of which more than 75.3 million people were reported to have been treated, 91% of whom live in Africa (5). In Nigeria, over 25 million people

are infected, thus, it is the most affected country in the world (16,17,18). Recent study in Jos North, Plateau State report that out of 100 samples examined in a primary school, the prevalence of urinary schistosomiasis among school aged children is 36% (17).

Freshwater snails belonging to the family Planorbidae are mostly known to be the intermediate host of parasitic blood flukes of the genus *Schistosoma* which cause schistosomiasis in most part of the world. Most intermediate hosts of human *Schistosoma* parasites belong to the three genera: *Biomphalaria* sp. serves as the intermediate host snails for *S. mansoni* in Africa and America, *Bulinus* sp. serves as the intermediate hosts of *S. haematobium* in Africa and the Eastern Mediterranean and *Oncomelania* sp. serves as the intermediate host of *S. japonicum* in southeast Asia (1,2). It is therefore very important to give attention to these fresh water snails that are capable of promoting transmission of water borne diseases among the vulnerable populations (19).

The World Health Organization (WHO) set a target by 2030 of schistosomiasis morbidity reduction of <5% prevalence in children aged 5–14 years by 2020 for endemic countries (13, 20). Despite efforts for a decade to mitigate the disease transmission, Nigeria is far from achieving the WHO's target. The Nigeria experience calls for the adoption of a holistic approach towards control of schistosomiasis. The integrated approach towards control of schistosomiasis could include intervention informed by appropriate and reliable mapping of the disease, ward level prevalence maps and

population data to estimate treatment needs, snail control, provision of safe water, and evidence-based decision making in policy development. This study investigated the influence of water physicochemistry on the distribution of Schistosomiasis in three selected communities within Jos North Local Government Area, Plateau State, Nigeria.

## Methods and materials

### Study area

The study was carried out in Jos North Local Government Area of Plateau State, Nigeria. It is the commercial center of Plateau State. Jos North has an area of 291 km<sup>2</sup>, located at approximately

9°55'N, 8°54'E and has a population of 729,300 at 2006 census. The indigenous ethnic group found in this area include: Berom, Anaguta, Afizere, and other ethnic groups (21) Jos north has many streams and pond or pools of water that are inter-connected. These bodies of water are often used for domestic activities, bathing and playing areas especially by children. The inhabitants of the areas are mostly peasant farmers, traders and civil servant. During the dry season their source of water is from the stream and pond, the inhabitants are engaged in indiscriminate disposal of feces in some areas, including the vicinities of the water bodies. The location selected for this study are Jenta Adamu, Tudun Wada and Student village Russau all in Jos north local government area.

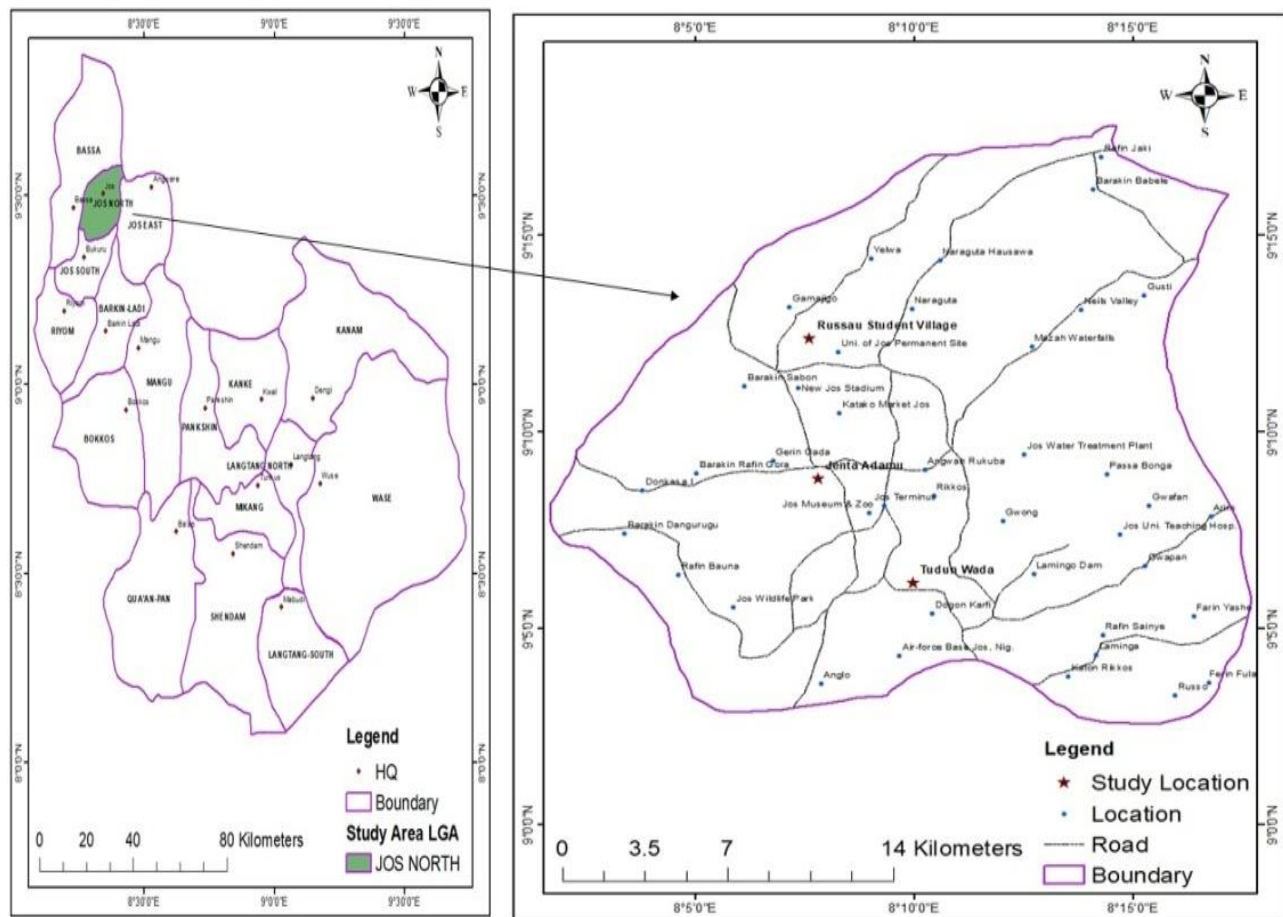


Figure 1: Map of Plateau State Showing Jos North Local Government Area, Nigeria.

Source: Researcher Field Study, 2021.

## Study design

The study employed a cross-sectional research design to investigate the influence of water physicochemical on the distribution of schistosomiasis in three selected communities within Jos North Local Government Area, Plateau State, Nigeria. This design allows for the collection of data at a single point in time to examine the relationships between the variables of interest.

## Sampling techniques

A purposive sampling technique was used based on local knowledge of water contact sites and snail presence. Purposive sampling was used to identify the specific freshwater bodies including; ponds, streams and irrigation canals. Jenta Adamu has ponds and streams, Tudun Wada (ponds, streams and irrigation canals) and Student village Russau has streams and irrigation canals all in Jos north local government area. Five areas were randomly selected from the water bodies in each of the selected communities.

## Collection of snails and water samples

Snail and water samples were collected from the selected water bodies after thorough survey and checks for the snail vectors in the water bodies and along the water banks. The snails were handpicked with hand gloves at the water banks and preserved. Water samples were also collected in a stoppered bottle immediately after the snail collection, and were fixed with alkaline iodide and manganese sulphate to prevent interferences with atmospheric oxygen before taken to the laboratory for analysis

## Snail identification

The snails were collected by hand picking with hand gloves. The collected snail samples were identified using morphological characteristic with the assistance of an expert in the Department of Zoology, University of Jos, using

standard taxonomic keys for freshwater snail identification (21).

## Physicochemical analysis of water samples

To ensure quality control, measurements were taken at the same sampling points and depth for all water bodies. All readings were conducted during a consistent time period of the day to minimize diurnal variation of parameters. Where necessary, duplicate measurement was taken and the mean value was recorded to improve reliability.

### Temperature (°C)

Water temperature of each water bodies was measured by lowering mercury in bulb thermometer few centimeters into the water surface of each water body for two minutes, in an incline position and temperature readings were taken using the standard laboratory method (22).

### pH

Hydrogen ion concentration (pH) of the test water in each water body was measured using digital pH meter (LABTECH-520). The pH meter was calibrated, dipped into the test media, allowed to stabilize and the reading was recorded for each water body (22).

### Conductivity (µS/cm)

Conductivity of the water in each water site was determined using a digital meter (LABTECH-523). The conductivity value was read off from the reader of the meter as the value stabilized and recorded for each of the water bodies (22).

### Total Dissolve Solute (mg/mL)

Total dissolve solute of the water in each water site was determined using a digital meter

(LABTECH-523). Total dissolve solute value was read off from the reader of the meter as the value stabilized and recorded for each of the water bodies (23).

### Salinity (mg/mL)

Salinity of each of the water site was determined using a digital meter (LABTECH-520). The salinity value was read off from the reader of the meter as the value stabilized and recorded for each of the water bodies (23).

### Dissolved oxygen (mg/mL)

The Alsterberg (Azide) method was used to determine the dissolve oxygen content in the water. Two (2) mL of manganese sulphate and 2 mL of alkaline iodine sodium oxide was added into the water and mixed by inverting the bottle several times. The sample was then mixed until the precipitate is dissolved, 200mL of the mixture was then poured into a conical flask; 1ml of 1% starch solution was then added to give the mixture blue-black colouration. The reading of the point when the mixture became clear was recorded. The volume (mL) of 0.025N sodium thiosulphate used in the titration was recorded and used to compute the dissolved oxygen content of the water samples. Dissolved oxygen was recorded in mg/L, (24).

$$\text{Dissolved oxygen (DO)} = \frac{(V_1 - V_2) \times N \times 8 \times 1000}{V_s}$$

Where: D =Sodium, V1 =Volume of titrant used for blank (mL), V2 =Volume of titrant used for sample (mL), N =Normality of sodium thiosulphate solution, Vs = Volume of sample analysed (mL), 8 = Milliequivalent weight of oxygen.

### Free Carbon (IV) oxide (CO<sub>2</sub>)

Free carbon (IV) oxide was measured using the method described by association of analytical chemist AOAC (24). One hundred (100) mL of

water from each water site was put into a conical flask. Ten (10) drops of phenolphthalein indicator was added and the clear solution was titrated with N/44 sodium hydroxide (NaOH) until a weak pink colour was observed. Free carbon dioxide was calculated in mg/L

$$\text{CO}_2 = 10 \times \text{mL of N/44 NaOH.}$$

### Data entry and analysis

All collected data were entered into excel, imported into STATA version 14.0 for statistical analysis. Chi square test of goodness of fit was used to assess if there was a significant difference in the number of snail species collected. Furthermore, one-way ANOVA test was used to ascertain if there was a variation in water quality parameter across the three sites of study. All results were considered significant at  $p < 0.05$ .

## Results

The record of the water quality parameters measured across the three study sites. Variations in temperature, pH, conductivity, Total Dissolved Solute, salinity, Dissolved Oxygen (DO), and Carbon dioxide (CO<sub>2</sub>) can significantly influence the aquatic ecosystem and the prevalence of schistosomiasis vectors. The study showed that all the studied parameters varied significantly across the three study locations ( $p < 0.05$ ) (Table 1).

The species of snails encountered in the study are contained in Table 2. Two snail species were encountered in this study: *Biomphalaria pfeifferi*, 123 (46.59%) and *Bulinus globosus*, 141 (53.41%). Although, *B. globosus* was the most abundant snail host encountered (53.41%), its abundance differs significantly from that of *Biomphalaria* s (46.59%) encountered ( $p = 0.031$ ).

Table 1: Variation in Water Quality Parameters across Study Sites

Study sites	Water quality parameter						
	Temp. (°C)	pH	Conduct. (µS/cm)	TDS (mg/L)	Salinity (mg/L)	DO (mg/L)	CO <sub>2</sub> (mg/L)
Jenta Adamu	26.80±0.42b	7.80±0.05c	578.6±6.00b	409.6±4.89b	219.8±3.17b	8.04±0.11b	13.4±0.75b
Tudun Wada	21.76±0.21a	6.94±0.07a	461.8±6.21a	331.0±3.75a	175.4±2.09a	5.56±0.63a	6.2±3.95a
Russau	29.12±0.08c	7.18±0.09a	741.6±1.94b	527.0±0.55c	277.8±4.47c	5.52±0.71a	41.0±3.19c

Keys: Temp-temperature; Conduct-Conductivity; TDS-Total Dissolved Solute; DO-Dissolved Oxygen; CO<sub>2</sub> - Carbon dioxide. Note: "Values in the same column followed by different uppercase superscripts" - The table uses uppercase letters (a, b, c).

Table 2: Snail Species Encountered in Jenta Adamu, Tudun Wada and Russau

Snail Species Encountered	Frequency	Percentage (%)
<i>Biomphalaria pfeifferi</i>	123	46.59
<i>Bulinus globosus</i>	141	53.41
<b>Total</b>	<b>264</b>	<b>100</b>

X=1.23, df = 1, p= 0.2679

In respect to study sites (Table 3), snail abundance was the same in both Jenta Adamu and Student village, Russau (45.45%) each respectively which was equally higher than what was collected in Tudun Wada (9.09%). While *Bulinus globosus* was the dominant snail species in Jenta Adamu (63.83%), however at Student Village, *Biomphalaria pfeifferi* (60.98%) was the dominant. While at Tudun wada, the dominant snail species collected was also *B. pfeifferi* (14.63%). Chi square test revealed that there was

a significant difference (p<0.05) in the abundance of snail host species collected across the three locations.

## Discussion

The water quality parameters were measured across the three communities. Seven out of the many physicochemical parameters of the three sites were measured; temperature, pH, conductivity, total dissolved solute, salinity, dissolved oxygen (DO) and carbon dioxide (CO<sub>2</sub>) can significantly influence the aquatic ecosystem and the prevalence of schistosomiasis vectors. Temperatures ranged between 21.76 to 29.12°C with Student village recorded the highest mean temperature (29.12±0.08°C) (25, 26). The recorded water pH values ranged between 6.94 and 7.80. The most alkaline pH was recorded in Jenta Adamu (7.80±0.05) even though there was no variation in water pH between the sites surveyed in Tudun Wada and

Table 3: Abundance of Snail Hosts in Respect to Jenta Adamu, Tudun Wada and Russau

Snail Species Identified	Study Sites			Total
	Jenta Adamu	Tudun Wada	Student Village Russau	
<i>Biomphalaria pfeifferi</i>	30 (24.39%)	18(14.63%)	75 (60.98%)	123(46.59%)
<i>Bulinus globosus</i>	90 (63.83%)	6 (4.26%)	45 (31.91%)	141 (53.41%)
<b>Total</b>	<b>120(45.45%)</b>	<b>24 (9.09%)</b>	<b>120 (45.45%)</b>	<b>264 (100%)</b>

X=42.4702, df= 2, p= 0.000

student village ( $p>0.05$ ). The value recorded in this study is similar with those reported by other researchers such as Urude et al. (27) in Kaduna, Abuja, Bauchi respectively. Conductivity ranged between 461.8 to 741.6 $\mu$ S/cm with the highest value recorded in Student village Russau (741.6 $\pm$ 1.94 suggesting a higher concentration of ions in the water. This value was higher than the value (38.3 $\pm$ 1.0 -320.0 $\pm$ 1.0  $\mu$ S/cm) reported by Nwoko et al. (2) who state that many studies have shown conductivity is a bio-indicator that reduce the distribution of fresh water snail intermediate host. The TDS value in this study ranged between 331.0 to 527.0mg/L, with the highest value recorded in Student village (527.0 $\pm$ 0.55) indicating a higher concentration of dissolved solids. On the other hand, the DO value ranged between 5.56 to 8.04mg/L, the highest was recorded at Jenta Adamu (8.04 $\pm$ 0.11) indicating better aeration in this location even though, there was no significant variation in DO values between Tudun Wada and Student village. Usman (29) reported that dissolved oxygen and CO<sub>2</sub> in water bodies play an important role in snail breeding, even if all other parameters are within the normal range. On the frequency and percentage distribution of two snail species: *Biomphalaria pfeifferi* and *Bulinus globosus*. These species are known vectors of schistosomiasis, a significant public health concern (3). The data from this study reveals that *Bulinus globosus* accounted for 53.41% of the total snail population, making it the dominant species in the sampled freshwater bodies. This species is a primary intermediate host for *Schistosoma haematobium*, which causes urogenital schistosomiasis. The higher frequency of *Bulinus globosus* indicates the presence of environmental conditions favorable for its growth and reproduction. Recent studies, such as that by Adekiya et al. (30), have linked higher prevalence of *Bulinus* species to moderate temperatures and slightly alkaline water pH in tropical regions. *Biomphalaria pfeifferi* constituted 46.59% of the total snail population. This species is an intermediate host for *Schistos-*

*oma mansoni*, which causes intestinal schistosomiasis. Although it is less prevalent than *Bulinus globosus*, the significant proportion of *Biomphalaria* suggests the potential risk of intestinal schistosomiasis in the studied sites. According to Adekiya et al. (30), *Biomphalaria* species tend to thrive in water bodies with low to moderate salinity and higher dissolved oxygen concentrations. The coexistence of *Biomphalaria pfeifferi* and *Bulinus globosus* indicates risks of schistosomiasis in the studied communities. This suggests that both urinary and intestinal forms of the disease are potentially endemic in these areas. Controlling snail populations in such ecosystems requires targeted measures, as different snail species may respond differently to environmental management practices. Recent research highlights the importance of monitoring water quality to mitigate the proliferation of these vectors (29). The dominance of *Bulinus globosus* suggests that the water bodies in these areas might be more favorable for species that prefer slightly alkaline and ion-rich conditions.

On the other hand, the substantial presence of *Biomphalaria pfeifferi* could be related to specific physicochemical parameters, such as higher dissolved oxygen levels and moderate temperatures. Recent findings by Adekiya et al. (30) & Urude et al. (29) indicate that such environmental characteristics strongly influence the abundance of these snail species. On the distribution of two snail species, *Biomphalaria pfeifferi* and *Bulinus globosus*, across the three study sites: Jenta Adamu, Tudun Wada, and Student Village, Russau. Both species are recognized vectors of schistosomiasis. The highest proportion of *Biomphalaria pfeifferi* was observed in Student Village Russau, accounting for 60.98% of the total *Biomphalaria* snails identified. In contrast, the species was less prevalent in Jenta Adamu (24.39%) and Tudun Wada (14.63%). This suggests that Student Village Russau provides more favorable environmental conditions for *Biomphalaria pfeifferi*, which is the intermediate host for

*Schistosoma mansoni*, the causative agent of intestinal schistosomiasis.

According to Adekiya et al., (30) and Usman et al. (29), *Biomphalaria* species often thrive in waters with relatively stable temperatures, neutral pH, and high dissolved oxygen levels. The distribution pattern seen in Student Village Russau might be linked to its physicochemical parameters, which likely create an optimal environment for these snails. In Jenta Adamu, *Bulinus globosus* accounted for 63.83% of the total *Bulinus* snails sampled, making this location the dominant site for this species. Student Village Russau accounted for 31.91%, while Tudun Wada had the lowest (4.26%).

The dominance of *Bulinus globosus* in Jenta Adamu aligns with findings by Adekiya et al. (30) who reported that *Bulinus* species are highly adaptable to slightly alkaline waters with moderate salinity and organic matter content. The minimal occurrence in Tudun Wada suggests that the environmental conditions may be less suitable for *Bulinus globosus*, possibly due to low ionic concentrations or limited food availability in the aquatic habitat.

The overall distribution indicates that Jenta Adamu and Student Village each contributed 45.45% of the total snail population, while Tudun Wada contributed only 9.09%. This pattern suggests that the ecological characteristics in Jenta Adamu and Student Village are conducive to supporting higher snail populations. High snail density is a known risk factor for schistosomiasis transmission. The low total snail count in Tudun Wada could indicate unfavorable conditions, such as lower temperatures ( $21.76 \pm 0.21^\circ\text{C}$ ) as well as low carbon dioxides ( $6.2 \pm 3.95$  mg/L) levels as recorded on the present study, all of which affect snail survival and reproduction (31). The results highlight the varying risk of schistosomiasis in the three locations due to differences in snail species prevalence.

## Conclusion

This study explored the effect of freshwater physicochemical properties on the distribution of schistosomiasis vector snails in some communities of Jos North. The findings revealed significant variations in physicochemical properties. Variations in temperature, pH, conductivity, Total Dissolved Solute, salinity, Dissolved Oxygen (DO) and Carbon dioxide (CO<sub>2</sub>) of freshwater. Two species of snail were encountered in this study: *Biomphalaria pfeifferi* and *Bulinus globosus*, with *B. globosus* as the most abundant snail host encountered (53.41%) when compared to *Biomphalaria* s (46.59%). In respect to study sites, snail abundance was the same in both Jenta Adamu and Student village, Russau (45.45%), higher than what was collected in Tudun Wada (9.09%).

## Acknowledgements

We are grateful to all the individuals who voluntarily participated in this study.

## Ethical considerations

Prior to conducting the research, ethical clearance was obtained from the state Ministry of Health Jos, Plateau state and Verbal permission from the local community members in Jenta Adamu, Tudun wada and Student Village, Russau. The approval number was MHJP/ADM/322/VOL.2/132

## Data availability statement

The data supporting the findings of this study are available from the corresponding author upon request.

## Conflicts of interest

The authors declare no conflict of interest

## Funding statement

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