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Research Article

Postprandial glycemia: How do Starchy Staple Meals Contribute to Glycemic Responses in Healthy Human Subjects?

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ABSTRACT

Postprandial blood glucose levels are influenced by starchy meals, which digest into glucose at different rates and have specific glycemic indices. These meals raise blood glucose concentrations at varying rates shortly after consumption. Therefore, consuming foods with minimal effects on postprandial blood glucose is beneficial for health and wellbeing. Starchy meals are staple foods in Nigeria, including rice, *eba* (cassava dough), and yam, which provide essential metabolic energy (glucose). This study evaluated the postprandial effects shortly after intake of these meals in 30 healthy individuals with body weights ranging from 40 to 85 kg, divided into six groups: a meal-deprived control group and five experimental groups, each with five participants. The meals tested were rice with fish stew, eba with jute leaf soup, and yam with egg sauce. Blood glucose levels were measured before the meal, after a 2-hour food deprivation, and at 10, 30, and 50 minutes post-meal. The results showed that rice caused the highest postprandial blood glucose spike ($p \leq 0.05$), while yam with egg sauce resulted in no significant change ($p > 0.05$). The study concluded that rice significantly increases postprandial blood glucose levels, indicating a high glycemic response. Thus, reducing rice intake may help manage diseases related to glucose metabolism, such as diabetes.

Keywords: *Blood glucose, Glycemic, Postprandial, Rice, Starchy foods, Yam*

INTRODUCTION

Postprandial blood sugar monitoring is essential in determining how the body responds to certain foods. By checking the blood sugar level after a meal, it may be possible to gain a better knowledge of how the human metabolic system is functioning (Keshet *et al.*, 2023). A rapid increase in blood sugar, or glucose spike, can indicate hyperglycemia, which is linked to serious health issues such as diabetes (Balaji and Kumar, 2019).

The consumption and digestion of carbohydrate-rich foods release various sugars into the bloodstream. However, glucose is the primary sugar affecting blood sugar levels, leading to insulin secretion (Wang *et al.*, 2020). After ingesting a carbohydrate-rich meal, blood glucose levels rise above the normal fasting plasma glucose range (70-110 mg/dl) (Prins *et al.,* 2023). According to the International Diabetes Federation (IDF), postprandial blood glucose levels should not exceed 140 mg/dl in non-diabetic individuals (Ceriello and Colagiuri, 2008).

To regulate blood glucose levels and store it for convenient access during the post-absorptive and fasting periods, the body releases insulin during the postprandial interval. The body's glucose levels increase throughout this period. Regular consumption of high-carbohydrate meals can lead to elevated postprandial glucose levels and frequent insulin release, potentially causing insulin resistance (Wali *et al.*, 2021). Insulin helps cells absorb glucose from the bloodstream, lowering blood sugar levels after meals. Persistent high blood sugar levels may indicate insulin resistance, a precursor to diabetes (Mathew *et al.,* 2023).

Hyperglycemia-related chronic diseases are major public health concerns worldwide. Thus, it is important to identify starchy meals that can aid in daily blood glucose management. In lifestyle-associated diseases, diabetes mellitus is thought to be closely related to dietary practices (Uuh and Segura, 2022). Diabetes can exacerbate conditions like diabetic retinopathy, nephropathy, and neuropathy. Nutritional and exercise therapies are essential for managing type 2 diabetes, with daily blood glucose control being key to improving prognosis and quality of life (Garber *et al.*, 2020). Although in some cases, intake of carbohydrates food components would cause postprandial hyperglycemia, certain foods (indigestible dextrin, wheat albumin, guava albumin, and L-Arabinose) prevent an increase in the blood glucose level after consumption (Saito, 2003).

The glycemic properties of starchy staple foods vary and can be classified as rapidly digestible starch (RDS) or slowly digestible starch (SDS). RDS is quickly absorbed in the duodenum, causing significant postprandial blood glucose changes and should be avoided by individuals with obesity or type 2 diabetes. SDS, on the other hand, digests slowly and has a moderate impact on postprandial glycemic response, benefiting those with type 2 diabetes (Gómez-Maqueo *et al.*, 2023). Foods are categorized by their glycemic index (GI), which reflects their impact on blood sugar levels. Low-GI foods cause gradual blood sugar increases, while high-GI foods cause rapid spikes. The GI can be a useful tool for people needing to monitor their blood sugar levels carefully, such as those with diabetes (Martinsson *et al.*, 2020).

The body absorbs refined carbohydrates (such as cereals, pasta, and dessert) faster and thus has a higher glycemic index. Whole food carbohydrates (like grains, vegetables, and fruits) are digested slowly by the body, so these have a lower glycemic index (Lee *et al.*, 2022). A sharp upsurge in blood sugar levels can be spurred by foods with a high glycemic index rating. Many of these foods have dietary benefits and are also rich in sugar. Low glycemic index foods, on the other hand, take longer to digest and gradually raise blood sugar levels. Since many of these foods are typically strong in fiber and other minerals, they may aid in controlling hunger while minimizing appetites (Evcili *et al.*, 2018).

Starchy foods are staple in many parts of Nigeria, providing necessary metabolic energy for daily activities. However, it is important to add to existing knowledge and scientific data on how these foods impact postprandial blood glucose. This study aims to investigate and provide data on the changes in postprandial blood glucose concentrations after consuming three starchy staple meals: rice with fish stew, cassava dough with jute leave soup (locally known as *eba* and *ewedu*), and yam with egg sauce in healthy individuals.

MATERIALS AND METHODS

The study was carried out at the Sagamu campus of Olabisi Onabanjo University, Ogun State, Nigeria. The medical supplies which include disinfectant Moko Isopropyl Alcohol (contains Alcohol B.P. 99.87%, a mixture of Isopropyl Alcohol 88.02%, Ethanol 11.84%, n-propanol 0.13% and Water 0.01%) from New Healthway Co. Limited, Nigeria, and Absorbent Cotton Wool were obtained. Food supplies needed for the experiment were purchased from Sabo Market in Sagamu, Ogun State.

Study subjects

Thirty (30) healthy human subjects aged 19 to 22 volunteered and participated in the study. All subjects, both males and females weighed between 40 and 85 kg. They were categorized into six (6) groups which includes the control group. Only the experimental groups had grouping based on gender and body weights: In the first group, subjects weighed 40 – 55 kg (denoted as Light); the second group, 56 – 70 kg (Middle); the third group, 71 – 85 kg (Heavy); the fourth (Male); and the fifth (Female).

Food preparation for food tests

The foods were expertly and freshly prepared in a clean, organized and hygienic environment. Each food type was made three times in nine days of the experiment. On the first three days, 13 cups of rice were prepared and was served with mackerel fish stew to each subject. On the next three days, they ate cassava dough with jute leaf soup (eba and ewedu soup), and sizable portion of beef. On the last three days, they were served yam with egg sauce. Each subject consumed 400 g portion of each food type throughout the experiment.

Physical tests

After a period of relaxation, about twenty minutes, post-arrival, the body temperature of each participant was measured on each test day to ensure they are in good condition to avoid alterations in the blood glucose readings. The body weight of each participant was also measured on each day.

Blood glucose test

The blood glucose test utilized for this study is the capillary blood glucose test which was carried out using the Accu-Chek glucometer and test strips – dehydrated glucose oxidase on a strip is rehydrated by the blood sample which then reacts with glucose to produce electrically detectable products (McMillin, 1990). The fingertip of each subject was disinfected and pricked with a lancet, thereafter a drop of blood was placed on the strip inserted into the glucometer. The glucose readings, i.e. concentrations in mg/dl, were displayed within seconds. The blood glucose test was done five times for all participants, i.e., i. on arrival ii. after a 2-hour meal-deprived period iii. 10 minutes after meal consumption iv. 20 minutes after the third reading v. 40 minutes after the third blood glucose test was done.

Experiment duration and meal schedule

The experiment spanned nine days, during which participants consumed three different starchy meals, each for three consecutive days. Specifically, from days 1 to 3, participants ate rice with fish stew; from days 4 to 6, they had eba with ewedu (jute leaves) soup; and from days 7 to 9, they consumed yam with egg sauce. With this setup the average glucose values for each type of meal were calculated.

Portion size and controlled environment

Each participant was served a consistent portion size of 400 g per meal. The experiment was conducted in a controlled environment free of distractions, with participants having their usual breakfast on each test day. The experiment commenced at 12 noon daily.

Initial measurements

Upon arrival, participants first had their body weight and temperature measured. Twenty minutes post-arrival, a baseline blood glucose test was conducted.

Meal deprivation period/second blood glucose test

Participants then underwent a two-hour period of no food intake. They were restricted from engaging in strenuous activities and using electronic devices to ensure accurate glucose readings. After the meal-deprived period, a second blood glucose test was administered.

Meal consumption/post-meal blood glucose tests

Participants then consumed the test meal of the day within 10 minutes, except for those in the control group who were meal-deprived throughout the entire experiment. Blood glucose levels were subsequently measured at 10, 30, and 50 minutes post-meal consumption. Control group participants also had their blood glucose tested at these intervals, despite not consuming any food.

Rate of change of blood glucose concentration is calculated with the formula below:

$$r1 = \frac{(Glc1 - Glc2)}{120};\ r2 = \frac{(Glc2 - Glc3)}{20};\ r3 = \frac{(Glc5 - Glc4)}{20};$$

$$r4 = \frac{(Glc5 - Glc3)}{40}$$

where r is rate of change in glucose levels. r1, end of fasting; r2, 10 minutes after meal from end of fasting; r3, 30 - 50 minutes after meal; r4, 10 - 50 minutes after meal.

Statistical analysis

Statistical package for social sciences (SPSS) software package v15.0 was used for data processing. Data analyses were done to compare the mean values of the blood glucose readings recorded at interval using one-way analysis of variance (ANOVA) and level of significance tested at $p \leqslant 0.05$ with Games Howell Post-Hoc test. The rate of change of blood glucose levels were calculated by the difference between mean values, divided by time interval, using the formula; rate (r) = ΔGlc(mg/dl)/time (minutes), Glc = blood glucose concentration.

RESULTS AND DISCUSSION

Results

Table 1. Postprandial Blood Glucose Concentrations (in mg/dl) of Participants of Rice with Fish Stew (Rfs) Group

	Glc1	Glc2	Glc3	Glc4	Glc5
Control	101.00 ± 3.10	94.80 ± 2.94	97.00 ± 3.11*	93.00 ± 1.70*	97.60 ± 3.82*
Light	104.00 ± 5.34	93.60 ± 3.30	135.20 ± 6.25*	140.80 ± 10.14*	140.20 ± 8.36*
Middle	99.00 ± 2.28	100.40 ± 3.14	126.00 ± 4.28*	122.40 ± 7.13*	122.40 ± 7.13*
Heavy	94.60 ± 5.44	106.20 ± 5.14	131.40 ± 2.09*	106.20 ± 5.14	119.20 ± 7.72
Male	98.60 ± 2.98	98.60 ± 5.99	135.60 ± 3.93*	142.20 ± 6.82*	131.20 ± 7.22*
Female	104.00 ± 5.34	106.60 ± 4.64	130.20 ± 5.04*	140.80 ± 10.14*	127.40 ± 11.43

Values are mean ± SEM, n = 5, * indicates significant difference at $p \leqslant 0.05$. Blood glucose concentrations: post-arrival baseline (Glc1); 2 hours postprandial (Glc2); 10 mins (Glc3), 30 mins (Glc4), and 50 mins (Glc5) post-meal.

Table 2. Postprandial Blood Glucose Concentrations (in mg/dl) of Participants of eba with Ewedu (Ees) Group.

	Glc1	Glc2	Glc3	Glc4	Glc5
Control	101.00 ± 3.10	94.80 ± 2.94	97.00 ± 3.11*	93.00 ± 1.70*	97.60 ± 3.82*
Light	105.60 ± 5.73	97.80 ± 0.66	117.00 ± 3.62*	125.40 ± 7.12*	113.40 ± 6.68
Middle	105.80 ± 5.92	99.00 ± 4.66	117.20 ± 2.70*	119.00 ± 6.57*	122.40 ± 7.13
Heavy	102.80 ± 7.37	99.00 ± 3.73	108.80 ± 4.20*	99.00 ± 3.73	102.40 ± 3.19
Male	107.00 ± 4.68	99.60 ± 4.39	120.00 ± 2.79*	129.00 ± 7.46*	123.20 ± 5.53*
Female	105.60 ± 5.73	98.20 ± 2.15	121.60 ± 3.26*	125.40 ± 7.14*	116.00 ± 7.82

Values are mean ± SEM, n = 5, * indicates significant difference at $p \leqslant 0.05$. Blood glucose concentrations: post-arrival baseline (Glc1); 2 hours postprandial (Glc2); 10 mins (Glc3), 30 mins (Glc4), and 50 mins (Glc5) post-meal.

Table 3. Postprandial Blood Glucose Concentrations (in mg/dl) of Participants of Yam with egg Sauce (Ywe) Group.

	Glc1	Glc2	Glc3	Glc4	Glc5
Control	101.00 ± 3.10	94.80 ± 2.94	97.00 ± 3.11*	93.00 ± 1.70*	97.60 ± 3.82*
Light	105.60 ± 5.73	95.40 ± 1.66	126.00 ± 4.22*	124.80 ± 8.67	118.40 ± 6.56
Middle	108.20 ± 6.12	96.00 ± 3.05	109.80 ± 3.09	101.80 ± 0.86	101.80 ± 0.86
Heavy	103.00 ± 5.99	94.80 ± 2.29	110.80 ± 6.69	94.80 ± 2.29	107.40 ± 5.07
Male	105.60 ± 4.84	100.60 ± 3.06	121.40 ± 8.32	105.40 ± 3.91	103.40 ± 1.12
Female	105.60 ± 3.10	92.80 ± 2.069	123.20 ± 5.94*	124.80 ± 8.67	116.60 ± 7.83

Values are mean ± SEM, n = 5, * indicates significant difference at p ≤ 0.05. Blood glucose concentrations: post-arrival baseline (Glc1); 2 hours postprandial (Glc2); 10 mins (Glc3), 30 mins (Glc4), and 50 mins (Glc5) post-meal.

Table 4. Rates of Change of Blood Glucose Concentrations (mg/dl/min) for the Food Categories.

	Rice with fish stew (Rfs)				Eba with ewedu soup (Ees)			
	r1	r2	r3	r4	r1	r2	r3	r4
Control	0.05	-0.11	0.23	-0.01	0.05	-0.11	0.23	-0.01
Light	0.09	-2.08	-0.03	0.13	0.07	0.96	-0.60	-0.09
Middle	0.01	1.28	0.00	-0.09	0.06	-0.19	0.17	0.13
Heavy	-0.09	-1.26	0.67	-0.31	0.03	-0.49	0.17	-0.16
Male	0.00	-1.85	-0.55	-0.11	0.06	-1.02	-0.29	0.08
Female	-0.02	-1.18	-0.67	-0.07	0.06	-1.17	-0.44	-0.13

r is rate of change in glucose levels. *r*1, end of meal-deprived period; *r*2, 10 minutes post-meal from end of meal-deprived period; *r*3, 30 - 50 minutes post-meal; *r*4, 10 - 50 minutes post-meal.

Discussion

In this study, we explored how three typical starchy meals commonly consumed in Nigeria impact blood sugar levels shortly after intake in healthy individuals. The implications of elevated blood glucose in certain disease conditions cannot be overemphasized. For instance, Type 2 diabetes mellitus (T2D) stands obvious in this case and its prevalence has been on a dramatic increase globally. Postprandial hyperglycemia (PH) is one of the major symptoms associated with poor glucose homeostasis in patients with T2D. The quality and quantity of carbohydrates are important factors in determining postprandial glucose concentrations because they have a major impact on the postprandial glycemic response (Salmerón*et al.,* 1997).

Elevated blood glucose levels (EBGL) in post-meal period: As expected, the blood glucose concentrations decreased for most of the participants during meal-deprived period. However, the ingestion of test foods caused significant increases, at p ≤ 0.05, of blood glucose in all the experimental groups compared to the control. In Tables 1 – 3, the increases occurred in the postprandial period, that is, in Glc3 to Glc5 for the three food types (Rfs, Ees, and Ywe) with differences ranging from 4 to 49 mg/dl glucose across the groups. There were insignificant changes in the blood glucose levels of the control group, at p ≤ 0.05. In contrast, noticeable changes in the mean glucose concentrations were observed in the experimental groups. More specifically, as shown in Table 1 for Rfs, there was an increase in EBGL from Glu3 to Glu4 (about 5 mg/dl) and stabilized in Glu5 within the Light group. Also, a decline from Glu3 to Glu4/Gluc5 (about 4 mg/dl) in the Middle was observed. The change was high in the Heavy group wherein an initial decline occurred from Glu3 to Glu4 (about 25mg/dl) and a slight increase from Glu4 to Glu5 (about 13mg/dl). The changes in EBLG were similar in both the Female and Male groups wherebythere was an increase in EBGL from Glu3 to Glu4 in Female (about 10 mg/dl) and in Male (about 7 mg/dl), but a decline of 11 and 13 mg/dl, respectively, occurred from Glu4 to Glu5.

Interestingly, the trend in the rice meal (Rfs) was similarly observed for the group that consumed eba (Ees) (Table 2). More specifically, in the Light group, the EBGL increased fromGlu3 to Glu4 (about 8 mg/dl) but then decreased from Glu 4 to Glu5 (about12 mg/dl) in contrast to the little or no change in blood glucose observed in Rfs. In the Middle group, there was an increase of about 2 to 3 mg/dl from Glu3 to Glu5. Meanwhile, the decline observed from Glu3 to Glu4 was about 9 mg/dl while the rise in blood glucose Glu4 to Glu5 was about 3 mg/dl which were comparably low to 25/13 mg/dl found in Rfs. Also for Ees, the changes in EBLG were similar in both the Female and Male groups – here, there was an increase in EBGL from Glu3 to Glu4 in Female (about4 mg/dl) and Male (about 9 mg/dl), but a decline of 9 and 6 mg/dl, respectively, occurred from Glu4 to Glu5. However, it is interesting to note here that, although these values followed an up-down trend in both genders, the observed differences in EBLG seemed not to be gender-dependent in nature as increases and decreases in them were seen from Glc3 to Glc4 and Glc4 to Glc5 or vice versa, with respect to rice and eba meals.

In general, the results found for the rice and eba meals revealed the overall body responses to the presence of glucose derived from the ingested foods (Son and Lee, 2015; Ogbonna et al., 2018). The trend was that the need to utilize glucose immediately after fasting was high which drove increased absorption and uptake of glucose into the bloodstream – apparently, this was dependent on the glycemic properties of the ingested foods. In this study, only the rice and eba (Rfs and Ees) meals caused significant changes ($p \leq 0.05$) observed in the blood glucose concentrations in the postprandial period tested (about 50 minutes). Although, another carbohydrate-rich yam meal (Ywe) tested in the current study was equally expected to elicit postprandial glucose response within the time allotted for observable differential glucose amount, surprisingly the mean blood glucose concentrations between the control and the experimental groups were not significantly different ($p > 0.05$) from each other (Yuniastutiet al.,2021). However, subtle significant differences were seen in Glc ten minutes shortly after meal (Glc3) in Light and Female groups, respectively (Table 3). We assumed these little impacts on the blood glucose may not have arisen from the inherent glycemic properties of the yam meal itself. It has been reported that yam has low postprandial glycemic index and its combination in paste with rice can lower the rice postprandial effects (Zhao et al., 2021).

Body weights vs. postprandial glucose: Although the effects of the starchy meals were observed on the glucose levelin the postprandial period (Glc3 to Glc5), it seemed the weight of the participants played noticeable influence on how glucose appears in their bloodstream for the all the categories in rice (Rfs) and eba (Ees) meals in the same way. Notably, it seemed longer postprandial period would be required to observed significant effects of the foods on blood glucose level in the Heavy category. The large negative mean differences from Glc3 to Glc5 (decrease/increase: 25/13 mg/dl in Rfs and 9/3 in Ees) suggests more time is needed to observe the glycemic response for the same amount of the meal consumed. In short, based on this proposal, the raise in blood glucose level relies on the glycemic properties of food and the weight of the individual.

Gender vs. postprandial glucose: The Impacts of the test foods on the postprandial glucose were also observed in the male and female categories. There were significant changes in blood glucose levels from Glc3 to end of the experiment. However, there were observable mean differences and the pattern of glycemic responses was similar in both groups. The blood glucose level was raised shortly after meal (Glc3 to Glc4) and lowers a few minutes (about 50 minutes) after meal for both food types, i.e. Rfs and Ees. This suggests that glycemic responses to these meals are gender-independent. The blood glucose response curve would have similarity when extrapolated for the same postprandial period in both gender for each meal. However, a longer postprandial period would be necessary to confirm this assertion.

Rice meal affected postprandial glucose the most: Although both rice and eba meals (Rfs and Ees) raised the blood glucose level in the postprandial period significantly ($p \leq 0.05$), the mean blood glucose values in all the categories in Rfs are generally higher than the Ees values (cf. Light: 135.2 vs 117.0 mg/dl, Middle: 126.0 vs 117.2 mg/dl, Heavy: 131.4 vs 108.8 mg/dl, Male: 135.6 vs 120.0 mg/dl, Female: 130.2 vs 121.6 mg/dl). The changes within each experimental group have been described above. However, in order to observe the rate of appearance (change) of glucose in the blood with respect to the meals, the rates calculated are presented in Table 4. The rate, r2, for Rfs is generally higher when compared to that of the Ees. The r2 ranges from 1.18 to 2.08 for the rice meal as compared to lower r2 rate in Ees in the 0.19-1.17 range. The implication of this faster rate of appearance of glucose in the bloodstream when rice was consumed is related to its glycemic properties. Interestingly, rice, in combination with other food components, is known to have relatively low glycemic index (Kameyama et al., 2014; Boer et al., 2015; Lu et al, 2017). Whether eba meal could compete or have even much lower glycemic number, given its mode of preparation, has been unravelled here. However, it is important to study the rates in eba over a longer postprandial time in the absence of other factors (intrinsic-extrinsic) that affect glucose metabolism.

Among the three starchy meals studied in this report, only yam and egg sauce appeared to have no or low glycemic response. It did not cause a spike in postprandial blood glucose, compared with the other two starchy foods. This is because yam is a slowly metabolized starchy food and does not digest as fast as compared with the other foods, thus, releases glucose into the blood much more slowly. It has been reported that tubers, such as yam, are considered high-fibre carbohydrate foods ideal for diabetics and individuals undergoing weight loss therapy, as they do not cause an extreme increase in insulin response (Slavin, 2008; Satija and Hu, 2012). Rice and fish stew on the other hand was found to be a high glycemic index food, as it had the highest postprandial response within the study time. Rice, a grain that is simple to digest and releases a lot of glucose into the bloodstream for the body to use as fuel, gives the body rapid energy. Particularly white rice has a detrimental impact on blood sugar levels since it has 45g of carbohydrates per cup, or almost as many as there are in a can of soda (38g). White rice has a severe flaw in that the bran and germ have been removed, leaving only the endosperm, making it a food with a high glycemic index that raises blood sugar levels after meals and raises insulin levels (Warastuti and Sudarti, 2023). More fibre is often present in low-GI diets, which has been shown to quickly reduce glycemic response and, as a result, postprandial fluctuations (Goncalves and Dullius, 2011). Therefore, a low-GI meal like yam and egg sauce or adding fibre to meals seem to be helpful techniques to improve postprandial response, for example, in T2D patients. These assertions are corroborated in a study by Yosuf et al. (2009a; 2009b) that compared high-GI/low-fibre meals to low-GI/high-fibre meals and found that the former decreased postprandial hyperglycemia.

CONCLUSION

In this study, we have investigated how three different starchy staple meals commonly consumed in Nigeria affected postprandial glycemia, shortly after intake, in healthy human participants. The results revealed that the meals i.e. rice with fish stew, eba with ewedu leaves soup increased the postprandial blood glucose concentration at different rates in about less than fifty minutes post-consumption. It is suggested that yam with egg sauce could impact the blood glucose level beyond the postprandial period tested as there was no significant shift in glucose levels within the study time. Nevertheless, the rate of release of glucose into the bloodstream by rice with fish meal was faster than the eba meal. These findings suggest rice with fish stew as a relatively high glycemic index food. This study offers preliminary scientific evidence regarding the influence of common starchy meals on blood glucose levels within two hours after eating. These findings could guide nutritional strategies, metabolic energy needs, and the management of sugar-related conditions, among other factors.

AUTHORS' CONTRIBUTIONS

Conceptualization, ASF and EOA; methodology, ASF; validation, KTO; formal analysis, ASF and EOA; investigation, AOO; resources, MMA; writing—original draft preparation, ASF; writing—review and editing, EOA. All authors have read and agreed to the published version of the manuscript.

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Ethical approval for this study was obtained from OOUTH Health Research Ethics Committee (OOUTH/HREC/800/2024AP).

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest associated with this work

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