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Original research

Efficacy of prophylactic use of intraoperative vancomycin powder in preventing surgical site infection in neurological surgeries in Irrua, Nigeria: A randomized controlled study

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ABSTRACT

Purpose: The objective was to determine the efficacy of intraoperative vancomycin powder in preventing SSIs in neurological surgeries.

Methods: A prospective randomized controlled study of patients who had clean cranial and non-implant spine surgeries at the Irrua Specialist Teaching Hospital, Irrua, Nigeria from February 1, 2021 to January 31, 2022. Patients were randomized into two groups. Group A patients had prophylactic intraoperative vancomycin powder applied to the surgical bed before wound closure while group B patients did not. Patients in both groups were followed up for 30 days post-operatively for evidence of SSI. The occurrence of SSIs was determined using clinical and laboratory parameters. Baseline characteristics, operative details, rates of wound infection, and microbiological data for each case were recorded. Data was analyzed using Statistical Package for Scientific Solution (SPSS) version 23 software.

Results: Forty–two patients were randomized into 2 groups of 21 patients each. The age range of the patients was 20 to 80 years. The majority of the patients were males (32 out of 42). The mean age of patients in group A was 48.05 ± 17.03 years, while group B had a mean age of 45.95 ± 19.14 years. The mean Body Mass Index of patients in groups A and B were 23.92 ± 5.21 and 23.21 ± 3.99 respectively.

Seven out of 21 patients (33.3 %) in the control group (group B) had superficial SSIs while no patient in the experimental group had SSI, p-value < 0.05. The organisms cultured were Klebsiella pneumoniae, Pseudomonas aeruginosa, and Staphylococcus aureus.

Conclusion: Intraoperative vancomycin powder was effective in reducing the rate of SSIs following neurological surgeries and without adverse drug reactions.

1. Introduction

Infections following neurosurgical procedures remain a great ordeal for neurosurgeons, more so in our environment. They cause enormous distress, pain, and psychological trauma to patients and they result in prolonged hospital stay, sometimes death [1,2]. Surgical site infection and its management impose a huge economic burden on patients, their families, the health care facilities, and the government, with significant loss of government revenue and work hours.

Surgical site infection (SSI) is defined as infection occurring in the surgical site within 30 days of surgery or one year of the use of implants [3]. It is the most common cause of post-operative infections in the developed world. In the United States of America, it accounts for 13.6 % of hospital-related infections with billions of dollars lost annually and attendant increased morbidity and mortality [4,5,6] Historically, intraoperative vancomycin powder was used for neurosurgical (cranial and spine) procedures, but was abandoned due to varied results [1,7,8]. However, there has been an upsurge in the re-introduction of intra-operative vancomycin powder in the last decade and a half [9]. Intra-operative vancomycin powder application on surgical wounds results in

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a high local antibiotic concentration at the surgical wound site with limited systemic toxicity when compared to intravenous vancomycin, which has widespread systemic distribution with relatively little local concentration and with potential profound systemic toxicity [4–9]. Reports over the last decade have shown a significant reduction of SSIs in patients who underwent spine implant surgeries from 4.7 % to 0.7 % with the use of intraoperative vancomycin powder [7]. Prophylactic intravenous vancomycin has variable bioavailability on surgical wounds, which hampers its ability to achieve high local bactericidal concentration as well as the additional risk of systemic drug reactions such as nephrotoxicity and hypersensitivity reaction. Thus, topical vancomycin produces high local antibiotic concentration at the surgical site while minimizing systemic toxicity [10,11]. Genuine adverse reactions to local vancomycin powder are uncommon [10]. Intraoperative vancomycin powder has been noted to have a minimal or low resistance profile due to slow systemic absorption.

Intraoperative vancomycin powder has been studied in several types of research involving spine instrumentations with promising findings in reducing surgical site infections, but very limited in cranial surgeries [12]. Vancomycin is a relatively cheap, readily available, and safe antibiotic with significant efficacy against staphylococcus species which are commonly implicated in SSI [13,14]. Vancomycin usage has significantly increased over the last decade due to increasing clinical data on its use in patients with methicillin-resistant staphylococcus aureus [14].

There is no reported prospective, randomized clinical controlled study assessing the safety or efficacy of intraoperative vancomycin powder among a neurosurgical population undergoing craniotomy or non-instrumented spinal procedures in Nigeria. Consequently, this study aimed to determine the efficacy of intraoperative vancomycin powder in preventing surgical site infections as well as the safety profile of intraoperative vancomycin powder in surgical wounds in neurological surgeries.

2. Methodology

This was a prospective, randomized controlled study involving patients who had clean cranial and spinal surgeries from February 1, 2021, till January 31, 2022.

Patients aged 18 and above, undergoing clean cranial surgeries (craniotomy, craniectomy, autologous cranioplasty) and clean spine surgeries (laminectomy, discectomy, laminoplasty) were recruited. Patients with pre-existing infections at or adjacent to the anticipated wound and those with cranial or spine implants were excluded.

1. The Sample size was calculated using the formula for Randomized Controlled Trial (RCT) [15]. The level of significance was 5 %, and power was 80 %. a statistical formula was used to calculate the sample size using the formula for randomized control trial, parallel two-tail, non-inferiority test significant level of 5 % and power of 80 % with a prevalence of SSI from previous studies at 1.9 %.
2. The block randomization technique was used to assign patients into Groups A and A, the sample size was 21 for each group, A, and B, and the total number of patients enrolled in this study was 42.

Ethical approval for the study was obtained from the Health Research and Ethics Committee of the hospital and informed consent was obtained from the patients.

2.1. Procedure

Patients were randomized in a 1-to-1 ratio into two groups named Group A and Group B using MS Excel 2013 to generate a table of random numbers for randomization.

All patients had general anesthesia, endotracheal intubation, and muscle relaxants.

All enrollees in both groups received standard prophylaxis of 1 g intravenous ceftriaxone which was administered at induction of anesthesia. However, one patient in the control group was given intravenous 500 mg levofloxacin due to previous history of cephalosporin allergy.

All patients had chlorhexidine and 10 % povidone-iodine skin preparation, and surgical sites were covered with impervious sterile drapes. Sharp dissection was done and electrocautery was used to secure hemostasis in all the patients. Six and five patients in groups A and B respectively were transfused with blood intra-operatively.

Group A patients (experimental group) had 1 g of topical vancomycin powder application before wound closure, while patients in the control group (group B) did not.

1 g of vancomycin was poured into the wound cavity (subfascial and subcutaneous plane) before the closure of the wound.

- No wound drain was used for patients in both groups.
- Wound closure: Wounds were closed in two layers. Vicryl 1 was used to oppose the fascia and subcutaneous tissue, while Prolene 2–0 was used to close the skin in an interrupted fashion. The wound was dressed with 10 % povidone-iodine.
- Patients were assessed for symptoms and signs of surgical wound infection, including fever or chills, increased pain, redness, swelling, or warmth at the surgical site, and wound discharge during wound inspection and at the point of discharge. Patients were followed up as outpatients weekly for 30 days after surgery, looking out for features suggestive of surgical site infections.
- Patients were monitored for adverse effects (AEs) of topical vancomycin such as rashes, urticaria, and erythema.

Those with evidence of surgical site infection had wound swabs for microbiology, culture, and sensitivity to identify infecting organisms and determine antibiotic sensitivity.

All SSIs were superficial and the patients had wound dressing with normal saline and antiseptic (10 % povidone-iodine) with appropriate antibiotics. Secondary wound closure was done when there was no clinical and laboratory evidence of infection with healthy granulation tissue. The sociodemographic data, co-morbid conditions, smoking history, intraoperative details, and post-operative outcomes were documented and analyzed. The primary outcome was the incidence of SSI.

Data was analyzed using Statistical Package for Scientific Solution (SPSS) version 23 software [15]. The level of significance was set at $P < 0.05$. Chi-square test, multivariate logical regression analysis, and Student *t*-test were used for the assessment of statistical significance.

3. Results

Forty–two (42) patients (21 in each group) who met the inclusion criteria were recruited.

The socio-demographic characteristics of patients are shown in

Table 1
Socio-Demography.

VARIABLE		GROUP A N = 21 (%)	GROUP B N = 21 (%)	x^2/T-test	p-value
Age	20–30	4 (19.0)	7 (33.3)		
	31–40	3 (14.3)	3 (14.3)		
	41–50	5 (23.8)	2 (9.5)	4.637	0.462
	51–60	4 (19.0)	1 (4.8)		
	61–70	4 (19.0)	6 (28.6)		
	71–80	1 (4.8)	2 (9.5)		
Mean age		48.05 ± 17.03	45.95 ± 19.14	0.375	0.710
Sex	Male	14 (66.7)	18 (85.7)	2.100	0.147
	Female	7 (33.3)	3 (14.3)		

The mean age of group A was 48.05 ± 17.03, while group B had a mean age of 45.95 ± 19.14. There were 14 (66.7 %) males in group A and 18 (85.7 %) in group B.

Table 1. The age range of the patients was 20 to 80 years. Thirty-two were males and ten were females with a male-to-female ratio of 3:1 as seen in Table 1.

The mean age of group A was 48.05 ± 17.03, while group B had a mean age of 45.95 ± 19.14. There were 14 (66.7 %) males in group A and 18 (85.7 %) in group B.

Table 2 shows the pre-operative clinical parameters. The mean BMI of groups A and B were 23.92 ± 5.21 and 23.21 ± 3.99 respectively. The major site of surgery in both groups was cranial, 57.1 % in group A and 95.2 % in group B.

Table 3. Topical vancomycin was used in all individuals in group A (100.0 %) and none in group B (0.0 %), being the control group. No side effects were observed. The estimated mean blood loss in groups A and B were 519.05 ± 107.87 and 310.24 ± 90.17 respectively. Intraoperative blood transfusion was required for 6(28.6 %) patients in group A and 5 (23.8 %) in group B.

The overall incidence of SSI was 33.3 % as shown in Table 4. Group A (Topical Vancomycin) incidence: 0.0 %, Group B incidence: 33.3 %.

Table 5; shows the relationship between various patients and clinical parameters and the incidence of surgical site infection. There was no statistical significance between the various groups ($p > 0.05$).

Table 6; shows the multivariate logistic regression model to determine predictors of SSI. It was of good fitting. There was however no statistical significance ($p > 0.05$).

Table 7. Topical vancomycin was shown to significantly prevent surgical site infection in neurological (cranial and spine) surgeries in the study population ($FET = 0.009$).

Table 8. Klebsiella pneumonia (14.3 %), Pseudomonas aeruginosa (14.3 %), and Staphylococcus aureus (28.6 %) were cultured in group B individuals. The antibiotic sensitivity pattern for the group B individuals was: Amikacin (28.6 %), Ceftriaxone (14.3 %), and Levofloxacin (28.6 %). The culture was negative in three patients. Cerebrospinal fluid (CSF) leak was not observed in group A individuals, while 9.5 % of group B individuals developed CSF leak which resolved spontaneously. No mortality was recorded among those with SSIs.

Table 3
Intra-operative clinical parameters/variables.

VARIABLE		GROUP A N = 21 (%)	GROUP B N = 21 (%)	x^2/T-test	p-value
Vancomycin powder use	Yes	21 (100.0)	0 (0.0)	42.000	**<0.001**
	No	0 (0.0)	21 (100.0)		
Any side effects of topical Vancomycin?	Yes	0 (0.0)	Nil	42.000	**<0.001**
	No	21 (100.0)	Nil		
Intra-operative blood transfusion	Yes	6 (28.6)	5 (23.8)	0.123	0.726
	No	15 (71.4)	16 (76.2)		
Estimated blood loss in ml (Mean)		519.05 ± 107.87	310.24 ± 90.17	1.485	0.145

Table 3. Topical vancomycin was used in all individuals in group A (100.0 %) and none in group B (0.0 %), being the control group. No side effects were observed. The estimated mean blood loss in groups A and B were 519.05 ± 107.87 and 310.24 ± 90.17 respectively. Intraoperative blood transfusion was required for 6(28.6 %) patients in group A and 5(23.8 %) in group B.

Table 4
Incidence of Surgical Site Infection in the Groups.

	Group A = 21 (%)	Group B = 21 (%)	x^2/T-test	p-value
Incidence of SSI among the groups	0 (0.0)	7 (33.3)	8.400	**0.004**
The overall incidence of SSI	7 (33.3)			

- The overall incidence: 33.3%.
- Group A (Topical Vancomycin) incidence: 0.0%.
- Group B incidence: 33.3%.

4. Discussion

This is the first report on the use of intra-wound vancomycin powder for prophylaxis in neurosurgery in Nigeria. It was observed that there was no surgical site infection in the intervention group, while a third of patients in the control group had superficial SSI, predominantly in the third and seventh decades of life. This corroborates the findings of Fang et al. who reported a higher rate of surgical site infection among patients above 60 years [16]. However, Saeedinia et al. reported that surgical site infection was more common in those less than 20 or greater than 50 years of age [17]. Caroom and co-authors in a similar study reported that the mean age for the control and treatment groups were 52.1 ± 16.6 years and 49.4 ± 15.6 years respectively which is similar to 48.05 ± 17.03 and 45.95 ± 19 years in this study [18]. This research findings in comparison with earlier research findings showed slight variation with peak age of surgical site infections. A major limitation of this study was the uneven distribution of those who had cranial and spinal procedures in both the experimental and control groups, as all patients who had SSIs (7 out of 21) in the control group had cranial procedures which accounted for 95.2 % 20 out of 21 (95.2 %) enrolled in Group B as this may influence the prevalence of SSIs recorded in this study. The majority of the patients in this study were males, (14 (66.7) in Group A, and 18 (85.7) in Group B, with a male-to-female ratio of 3:1, although age; and sex as determinants of SSIs were statistically not significant as seen in Table 1. Korinek et al. previously reported the male gender as a non-modifiable risk factor for surgical site infection and this was confirmed by this study [19]. Although, the male preponderance of the

Table 2
Pre-operative clinical presentation/risk factors.

VARIABLE	GROUP A N = 21 (%)	GROUP B N = 21 (%)	x^2/T-test	p-value	
Presence of co-morbidities	Yes	9 (42.9)	8 (38.1)	0.099	0.753
	No	12 (57.1)	13 (61.9)		
2. ASA Score		GRADE 1–13 (61.9)	GRADE 1–9(42.9)	3.2730.195 GRADE	0.195
		GRADE 2–8(38.1)	GRADE 2–12(57.1)		
3. Immunosuppressive drugs	Yes	4 (19.0)	0 (0.0)	4.421	**0.035**
	No	17 (81.0)	21 (100.0)		
4. Smoking	Yes	2 (9.5)	3 (14.3)	0.227	0.634
	No	19 (90.5)	18 (85.7)		
5. BMI (mean)		23.92 ± 5.21	23.21 ± 3.99		
6. Site of surgery	Cranial	12 (57.1)	20 (95.2)	8.400	**0.004**
	Spine	9 (42.9)	1 (4.8)		
7. Name of prophylactic IV antibiotics	Levofloxacin	1 (4.8)	0 (0.0)		
	Ceftriaxone	20 (95.2)	21 (100.0)		

Table 2 shows the pre-operative clinical parameters. The mean BMI of groups A and B were 23.92 ± 5.21 and 23.21 ± 3.99 respectively. The major site of surgery in both groups was cranial, 57.1 % in group A and 95.2 % in group B.

Table 5
Relationship between various patient clinical parameters and incidence of Surgical Site Infection (SSI).

Parameters	SSI Present Frequency (%)	SSI Absent Frequency (%)	x^2	*p*-value gender
Gender				
Male	5 (71.4)	27 (77.1)	0.105	0.746
Female	2 (28.6)	8 (22.9)		
Age			9.011	0.109
Co-morbid conditions				
Smoking				
Yes	0 (0.0)	5 (14.3)	1.135	0.287
No	7 (100.0)	30 (85.7)		
Obesity				
Yes	1 (14.3)	4 (11.4)	0.045	0.831
No	6 (85.7)	31 (88.6)		
Comorbidities (HTN, DM)				
Yes	4 (57.1)	13 (37.1)	0.968	0.325
No	3 (42.9)	22 (62.9)		
Site of surgery				
Cranial	7 (100.0)	25 (71.4)	2.625	0.105
Spine	0 (0.0)	10 (28.6)		
Use of immunosuppressives				
Yes	0 (0.0)	4 (11.4)	0.884	0.347
No	7 (100.0)	31 (88.6)		
Estimated blood loss				
<200 ml	4 (57.1)	18 (51.4)	0.076	0.782
≥200 ml	3 (42.9)	17 (48.6)		

Table 5; shows the relationship between various patients and clinical parameters and the incidence of surgical site infection. There was no statistical significance between the various groups ($p > 0.05$).

Table 6
Multivariate Logistic Regression Model to determine predictors of SSI.

Parameters	**Odds ratio (95 % CI)**	***p-value***
Age	1.062 (0.929–1.214)	0.380
Sex		
Male	8.316 (0.267–258.817)	0.227
Female		
Obesity		
Yes	0.639 (0.395–1.034)	0.068
No		
Smoking		
Yes	0.000 (0.000–0.000)	0.999
No	0.000(0.000–0.000)	0.999
Use of Immuno-**suppresants**		
Yes		
No		
Intraoperative blood loss		
<200 ml	1.154 (0.068–19.505)	0.921
≥200 ml		
Presence of comorbidities		
Yes	0.025 (0.000–3.425)	0.142
No		
Surgical site		
Cranial	0.000 (0.000–0.000)	0.998
Spine		

Table 6; shows the multivariate logistic regression model to determine predictors of SSI. It was of good fitting. There was however no statistical significance ($p > 0.05$).

Table 7
Cross-tabulation and Chi-Square analysis of Topical Vancomycin application and Presence of Surgical Site Infection.

USE OF TOPICAL VANCOMYCIN	SURGICAL SITE INFECTION		
	Yes N (%)	No N (%)	Total
Yes	0 (0.0)	21 (60.0)	21
No	7 (100.0)	14 (40.0)	21
Total	7	35	42

Level of significance: 0.05.
df = 1; *Fisher's Exact Test: 0.009.*
Table 7. Topical vancomycin was shown to significantly prevent surgical site infection in neurological (cranial and spine) surgeries in the study population (FET = 0.009).

participants in this study may be responsible for this finding. In contrast to previous reports of low surgical site infection rates of 4–8.9 % following cranial surgeries, the surgical site infection rate in the control group for this study was high at 33.3 % [20,21,22,23,24]. This high rate may be due to differences in policy/ protocols for surgical site infection and infection control in our setting compared to countries with more developed and active infection prevention and control systems/protocols. This may be further explained by the apparent lack of institutional infection surveillance measures which is a common denominator in low- and middle-income countries like ours, as well as the relatively small sample size of this study.

Previous studies have reported diseases such as hypertension, obesity, diabetes mellitus, human immunosuppressive virus (HIV) infection, malignancy, and chronic kidney disease [25,26,27,28,29,30,31,32,33], as predisposing factors to surgical site infections. However, there was no significant association between these diseases and the rate of SSI in this study. The relatively small sample size may result in the underpowering of this study and may explain why there was no significant association between these diseases and SSI in this study.

Smoking has been reported as a risk factor for SSI following spine surgeries but this was not confirmed by this study [34,35] This may be due to the low incidence of smoking among the study participants (5 out of 42), as Table 2 showed it was not statistically significant. However, Table 2 showed that immunosuppressive drugs and the site of surgery concerning the risk of SSIs were statistically significant with a p-value less than 0.05.

This study demonstrated the efficacy of intra-operative intra-wound vancomycin powder application in preventing surgical site infection as no patient in the treatment group developed surgical site infection as shown in Tables 4, and 7. This lends credence to previous reports of the effectiveness of intra-operative intra-wound vancomycin powder application in preventing surgical site infection [18,36,37,38]. The initial report supports the effectiveness of intra-operative intra-wound vancomycin powder application in reducing the rate of SSI in instrumented spinal procedures [39]. However, Bikram et al. suggested the routine use of intra-operative intra-wound vancomycin powder as an

Table 8
Postoperative outcome.

VARIABLE		GROUP A N = 21 (%)	GROUP B N = 21 (%)
Wound dehiscence	Yes	0 (0.0)	2 (28.6)
	No	0 (0.0)	5 (71.4)
		N = 0 (%)	**N = 7**
Wound discharge	Yes	0 (0.0)	4 (57.1)
	No	0 (0.0)	3 (42.9)
		N = 0 (%)	**N = 7**
Skin changes around the wound	Yes	0 (0.0)	6 (85.7)
	No	0 (0.0)	1 (14.3)
		N = 0 (%)	**N = 7**
Organism cultured	**Klebsiella pneumonia**	Nil	1 (14.3)
	Pseudomonas aeruginosa	Nil	1 (14.3)
	Staphylococcus aureus	Nil	2 (28.6)
		N = 0 (%)	**N = 4**
Antibiotic pattern	Amikacin	Nil	2 (28.6)
	Ceftriaxone	Nil	1 (14.3)
	Levofloxacin	Nil	2 (28.6)
		N = 21 (%)	**N = 5**
CSF leak	Yes	0 (0.0)	2 (9.5)
	No	21 (100.0)	19 (90.5)
		N = 21 (%)	**N = 21 (%)**

Table 8. Klebsiella pneumonia (14.3%), Pseudomonas aeruginosa (14.3%), and Staphylococcus aureus (28.6%) were cultured in group B individuals. The antibiotic sensitivity pattern for the group B individuals was: Amikacin (28.6%), Ceftriaxone (14.3%), and Levofloxacin (28.6%). The culture was negative in three patients. Cerebrospinal fluid (CSF) leak was not observed in group A individuals, while 9.5% of group B individuals developed CSF leak which resolved spontaneously. No mortality was recorded among those with SSIs.

essential adjunct to asepsis in neurosurgery [40]. They hypothesized that topical vancomycin powder use reduces surgical site infection rate in neurological surgeries by directly acting on any local inoculum at the time of surgical intervention. Blood loss during surgery has been identified as one of the risk factors for SSIs [20,22,23]. The average blood loss in groups A and B were 519.05 ± 107.87 and 310.24 ± 90.17 respectively as shown in Tables 3 and 5, and it was not statistically significant, this could account for the majority of those who had spinal procedures in group A (9 out of 10 in both groups). This study was unable to draw a correlation between the amount of blood loss and SSIs. This may be attributable to the relatively small sample size of this study.

As earlier reported by Radwanski, in a comparative study on the use of intra-operative intra-wound vancomycin, there was no adverse effect nor evidence of toxicity with the use of intra-operative intra-wound vancomycin powder in this study [41]. However, Mariappan et al. [42] reported two cases of systemic effects of vancomycin after intra-operative intra-wound vancomycin powder application, but this was not statistically significant (0.001 % with a p-value > 0,05). Hence, intra-operative intra-wound vancomycin powder application is considered safe. There was no incidence of vancomycin-resistant micro-organisms in this study as reported by other authors.

As previously reported by other authors such as Mallela et al, Abdullah et al and others, the most common cause of SSI in this study was Staphylococcus aureus, while other organisms cultured were Klebsiella pneumonia and Pseudomonas aeruginosa as shown in Table 8. This supports the fact that Staphylococcus aureus is the most common cause of SSI globally and measures to prevent this infection such as the use of intra-wound vancomycin powder to which the organism is susceptible should be encouraged and further studied [12,17,18,21,38].

The only report found in the literature contrary to the findings of the study was by Salimi et al. who reported that intra-wound vancomycin has no effect on SSI and that it can increase the rate of gram-negative infections. However, their findings have not been corroborated by other authors [43].

The Limitations of this study include;

1. The culture was limited to aerobic media only, as this excluded the possibility of identifying anaerobic and fungal organisms
2. Relatively small sample size.
3. Uneven distribution of patients who had cranial and spinal procedures.

5. Conclusion

Intra-wound vancomycin application significantly reduced the risk of surgical site infection in patients who have clean non-implant cranial and spinal surgeries with no apparent sign of systemic toxicity or side effects.

Recommendation

1) Intra-wound vancomycin application before wound closure is recommended for clean cranial and spinal surgeries.
2) Large-scale multicenter studies on intra-wound vancomycin application in neurosurgical practice should be done to verify the findings of this study.

Funding

No funding was received for conducting this study.

7. Code availability

Coded information as related to data are available.

8. Availability of data and material

All data and materials related to this research are available and can easily be assessed by the journal.

Ethical approval

Approval for the study was obtained from the Health Research and Ethics Committee of the Irrua Specialist Teaching Hospital. This study was performed in line with the principles of the Declaration of Helsinki.

CRediT authorship contribution statement

E. Morgan: Conceptualization, Funding, Writing – original draft, Writing – review & editing, Methodology, Resources, Investigation, Formal analysis. **J.E. Onuminya:** Supervision, Methodology, Validation, Resources. **C.O. Osime:** Supervision, Methodology, Validation. **B. O. Adebayo:** Validation, Project administration, Software. **O. Ehioghae:** Investigation, Data curation, Formal analysis. **B. Adetunmbi:** Validation, Visualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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