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Antimicrobial stewardship competencies in undergraduate dental education: a multicentre cross-sectional study of clinical dental students in Southern Nigeria

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Abstract

Background Antimicrobial stewardship (AMS) is a crucial global health initiative aimed at promoting rational antimicrobial use to curb the rising threat of antimicrobial resistance (AMR) and improving patient outcomes. Dental practitioners contribute significantly to antibiotic prescribing in ambulatory care, yet AMS competencies among dental students, particularly in Nigeria, remain underexplored. This study assessed the knowledge, attitudes, and opinions regarding AMS among clinical dental students across southern Nigeria.

Methods A multicentre cross-sectional survey was conducted among 160 clinical dental students from three universities in southern Nigeria. Participants were selected using stratified random sampling based on institutional enrolment proportions. A 38-item pretested questionnaire assessed AMS-related knowledge, attitudes, and opinions. Responses were scored based on correctness and confidence, then categorized as Good, Fair, or Poor. Logistic regression models were used to assess associations between AMS scores and demographic factors.

Results The mean age of participants was 25 years (SD = 3), with a gender distribution of 51.88% females and 48.12% males. A generally positive knowledge and attitude towards AMS were observed; however, significant demographic variations were identified. Male students, students from minority ethnic groups, younger participants, and Muslims demonstrated higher AMS competencies. A strong positive correlation was found between knowledge and attitude scores. Gender and marital status were significantly associated with knowledge scores ($p = 0.016$ and $p = 0.004$, respectively), while marital status also influenced attitude scores ($p = 0.0338$). Institutional differences revealed lower AMS knowledge scores among students from the University of Nigeria compared to other schools.

Conclusion While clinical dental students in southern Nigeria demonstrated adequate baseline knowledge and attitudes toward AMS, demographic disparities highlight the need for targeted educational interventions.

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Standardized AMS curricula across dental schools, with culturally sensitive and gender-inclusive approaches, are recommended to enhance stewardship preparedness and contribute to global AMR mitigation efforts.

Keywords Antimicrobial stewardship, Dental education, Antimicrobial resistance, Undergraduate education, Antibiotic prescribing, Nigeria, Medical education

Introduction

Antimicrobial stewardship (AMS) is a global health priority aimed at optimizing antimicrobial use to improve clinical outcomes and combat the growing threat of antimicrobial resistance (AMR) [1, 2]. The World Health Organization has underscored the need for integrating AMS training into undergraduate healthcare education to promote rational prescribing practices early in clinical careers [2].

AMS entails the appropriate selection, dosing, and duration of antimicrobial therapy to achieve optimal patient outcomes with minimal resistance development and toxicity [3, 4]. Despite its importance, studies have consistently revealed inadequate AMS preparedness among medical and dental students, with many expressing low confidences in their prescribing competencies [5, 6].

In Nigeria, dental students spend significant time—approximately 800 h—studying pathology and pharmacology during their clinical training [7]. However, this training may be insufficient for fostering sound antimicrobial prescribing behaviour. Inappropriate prescription decisions driven by limited AMS knowledge can contribute to the rising burden of resistance [8]. This concern is particularly relevant given that dental practitioners play a substantial role in antibiotic prescribing globally.

Dentists contribute approximately 10% of all outpatient antibiotic prescriptions in many countries. In Norway, for example, dentists account for 5.9% of ambulatory antibiotic use, while in the United Kingdom, they were responsible for 4.7% of such prescriptions in 2020 and 11% in the United States [8–11]. These figures highlight the critical role of dentists in antibiotic stewardship and the potential consequences of inappropriate prescribing, including the emergence of resistant strains and increased healthcare costs.

Evidence indicates widespread inappropriate use, particularly for prophylaxis and non-severe infections, which contributes to AMR [11–13]. Although dental curricula include foundational pharmacology and pathology training, many do not incorporate current AMS guidelines or best practices [14–17].

In Nigeria, where over-the-counter antibiotic access and inconsistent prescribing practices are common among clinicians [18], the role of dental students who are future prescribers becomes even more critical. Southern Nigeria, home to the largest concentration of dental schools, presents a unique opportunity to evaluate preparedness in AMS.

Despite the central role dentists play in antibiotic prescribing, no formal study has assessed AMS-related competencies among clinical dental students in Southern Nigeria. This region hosts the largest concentration of dental institutions, yet stewardship training remains under-evaluated.

Previous studies have explored demographic influences on antimicrobial stewardship (AMS) knowledge and practices. Older students and practitioners often demonstrate higher AMS awareness, potentially due to greater clinical exposure [19]. Male gender has been variably associated with either more confident or risk-taking prescribing behaviors, depending on cultural and educational contexts [20]. Religion can also influence AMS through moral frameworks regarding drug use, ethical responsibility, and adherence to medical guidelines. Understanding these demographic correlates is critical for tailoring AMS education to diverse student populations in Nigeria.

This study aimed to assess AMS competencies—comprising knowledge, attitudes, and opinions—and examine the impact of demographic and institutional differences, thereby identifying gaps in AMS preparedness within undergraduate dental education and providing evidence to guide curriculum enhancement and stewardship training.

Methodology

Study design

This was a cross-sectional study involving the clinical dental students, in their 500 level (penultimate) and 600 level (final year) of study, in accredited dental schools in southern Nigeria.

Study area

Nigeria is administratively divided into six geopolitical zones—North Central, North East, North West, South East, South South, and South West. These zones group the 36 states and the Federal Capital Territory based on similarities in ethnicity, culture, and geography. Though not constitutionally defined, they serve important roles in governance, policy planning, and academic research across sectors including education and public health [21].

The study was conducted at the University of Nigeria Enugu Campus (UNEC) located in the Southeast

region, Lagos University Teaching Hospital (LUTH) and University of Port Harcourt, College of Medicine, Chaoba located in the Southwest and south-south regions respectively.

University of Nigeria Enugu Campus (UNEC) has her 500 level clinical students located in the Enugu metropolis while her final year clinical students are located at the teaching hospital at Ituku-Ozalla villages of Nkanu East LGA, Enugu State. However, the clinical dental students of the University of Port Harcourt are located at the Teaching hospital at Chaoba, an urban area in Rivers State.

Furthermore, the clinical dental students of the University of Lagos are located at the teaching hospital, LUTH which is situated in the suburban area of Idi-Araba, Lagos State.

The three universities were chosen because they represent each of the three southern geopolitical zones of Nigeria, are fully accredited by the National Universities Commission (NUC) and Medical and Dental Council of Nigeria (MDCN), and had available clinical dental students at the time of study, ensuring both geographical spread and institutional diversity.

Study population
The study was among clinical dental students in the selected dental schools in southern Nigeria.

Sample size determination
Using Taro Yamane's formula for sample size determination as stated by Tepping, 1968 [22], where the confidence level was set at 95%, and an allowable error of 5% in a population of 264, the needed sample size was calculated to be 159.

$$n = \frac{N}{1 + N(e)^2}$$

N = 264; school from Southwest: 500 level = 29, 600 level = 36; total = 65.

School from South-South: 500 level = 13, 600 level = 4; total = 17.

School from South-East: 500 level = 117, 600 level = 66; total = 183.

∴ Total South-West + Total South-South + Total South-East.

= 65 + 17 + 183 = 264.

Where :

n = sample size required.

N = number of people in the population = 264.

e = allowable error (%) (5% or 0.05).

Therefore, the sample size is

$$n = \frac{264}{1 + 264(0.05)^2}$$

$$= 159.01$$

Inclusion criteria
All dental students in their 500 level and 600 level in the chosen dental schools who gave consent to participate in the study were included in the study.

Exclusion criteria
All the students who were not dental students, dental students not in their 500 level or 600 level, and dental students in their 500 level and 600 level that did not give their consent to participate in the study were excluded from the study.

Sampling technique
A multistage sampling was employed for this study. Firstly, purposive sampling technique was used to select the southern region of the study area. Furthermore, the regions were stratified into South-West, South-East and South-South geopolitical regions. A dental school was randomly selected each from the South-West and South-South regions from a total of 3 dental schools in the South-West and South-South geopolitical zones respectively using the balloting method as the University of Nigeria is the only accredited dental school in the South-East as at the time of the study.

Subsequently, stratified random sampling method was used to divide the population into strata, to get the proportionate sample of students in each school and an equal number of respondents. Using the students number made available by each school on request, the number/population of students in each school were obtained.

$$Sample\ ratio = \frac{sample\ size}{study\ population}$$

Where sample size is 159 and study population 264, therefore, the sample ratio is 0.6.

Therefore, Sample for Southwest = 65 × 0.6 = 39.

Sample for South-East = 183 × 0.6 = 109.

Sample for South-South = 17 × 0.6 = 10.2.

Within each school, proportionate stratified random sampling was used. For example, in the South-West (65 students total, 29 in 500 L, 36 in 600 L), the required 39 participants were distributed proportionally: (29/65 × 39 ≈ 17 from 500 L; 36/65 × 39 ≈ 22 from 600 L). Similarly, in the South-East (183 students, 117 in 500 L, 66 in 600 L), the 109 participants were allocated proportionally: ≈70 from 500 L and ≈39 from 600 L. In the South-South (17 students, 13 in 500 L, 4 in 600 L), the 10 participants were distributed as ≈8 from 500 L and ≈2

from 600 L). Proportionate stratified random sampling was employed to minimize selection bias.

Ethical clearance

Ethical approval was obtained from the College of Medicine Research Ethics Committee (COMREC) of the University of Nigeria with the protocol no NHREC/COMREC/0158/03/2023. Prior to participation, all individuals provided written informed consent, confirming their comprehension of the study's objectives, methods, and potential risks. Participation was entirely voluntary, and individuals reserved the right to withdraw at any stage without penalty or consequence. To ensure confidentiality, all collected data were securely stored in anonymized systems, adhering to the ethical standards outlined in the Declaration of Helsinki for human subject research. In compliance with Nigeria's National Health Research Ethics Committee (NHREC) policy, anonymized data will be securely stored for five years after publication.

Study tool and data collection

Data were collected between February and April, 2023 using a structured self-administered questionnaire distributed in-person during clinical postings. The questionnaire comprised four sections: [1] demographics (age, gender, religion, marital status, year of study) [2], knowledge items on AMS principles [3], attitudes towards AMS, and [4] opinions on antimicrobial prescribing. The full questionnaire is provided as Supplementary File 1.

The questionnaire was pretested among 20 clinical medical students from a non-participating institution. It was reviewed by two experts in antimicrobial stewardship and revised for clarity and content validity. Internal consistency was confirmed with a Cronbach's alpha of 0.82. It comprised sections A to D that deals with the participants' demographics, knowledge on antimicrobial stewardship, attitude of students and opinions of students on antimicrobial stewardship respectively. The structured questionnaire was distributed in person during clinical postings, coordinated through class representatives, and collected immediately after completion to ensure a high response rate.

Data collection procedure

Participants were approached during clinical postings, informed about study objectives, and written consent obtained. Data were collected by trained three research assistants (final-year medical students) and the authors supervised by faculty. Each questionnaire took 5–10 min. Completed forms were checked daily for errors before entry. Confidentiality was ensured by anonymizing responses. Data were stored electronically in password-protected systems, backed up on encrypted drives, and will be retained for five years post-publication in line with Nigerian research ethics policy.

Data handling and analysis

Data analysis was conducted using Python (Python Software Foundation, version 3.10, 2023), employing standard data analysis libraries such as pandas for data manipulation, numpy for numerical computation, and scipy and statsmodels for statistical analysis. Frequency, percentages, means, standard deviations and median were summarized into categorical and continuous variables. Associations between categorical variables were analysed using chi square. The statistical significance was set at $P < 0.05$.

The survey questions were carefully categorized to assess three key aspects: opinions, knowledge, and attitudes towards Antimicrobial stewardship. To evaluate participant responses, a scoring system was developed based on the level of agreement or disagreement with each statement.

For statements with correct answers being "true," the scoring was as follows: participants who strongly agreed scored 4 points, those who agreed scored 3 points, neutral responses scored 2 points, disagreements scored 1 point, and strong disagreements scored 0 points. Conversely, for statements with correct answers being "false," the scoring system was reversed: strong agreement scored 0 points, agreement scored 1 point, neutral responses scored 2 points, disagreements scored 3 points, and strong disagreements scored 4 points.

This scoring system allowed for a comprehensive comparison of participant responses to the perfect score, which would be achieved if a participant answered all questions with certainty and correctness. The knowledge was scored 0 to 4 based on the Likert scale with Strongly disagreeing to the right knowledge 0, disagree = 1, neutral = 2, agree = 3 and strongly agree 4 also for the attitude section. Therefore, the maximum number of marks a person can score is 40 and a minimum of 0. The responses scoring less than 10 was regarded as poor, 10 to 30 was regarded as fair while 31 to 40 was regarded as good knowledge, attitude and/or opinion.

Results

Participant demographics

A total of 160 participants were included in the study, with a mean age of 25 years (SD = 3) (Table 1). Among the participants, 83 (51.88%) were female. In terms of marital status, 149 (93.12%) were single, while 11 (6.88%) were married. The sample consisted of two major ethnic groups, with 50 (31.25%) participants identifying as Yoruba, 96 (60%) as Igbo, and 14 (8.75%) from other ethnic groups.

Table 1 Sociodemographic characteristics of the study participants

Variable		Frequency (*n*)	Percentage (%)
Age as at last birthday		Mean 25 ± 3	
Gender	Female	83	51.90
	Male	77	48.10
Marital status	Married	11	6.90
	Single	149	93.10
Ethnicity	Igbo	96	60.00
	Yoruba	50	31.0
	Others	14	8.80
Religion	Christianity	135	84.40
	Islam	19	11.90
	Others	6	3.80
School	University of Nigeria	111	69.40
	University of Lagos	33	20.60
	University of Port Harcourt	16	10.0
Level of study	500	43	26.90
	600	117	73.10
Geopolitical zone	South-East	111	69.40
	South-South	16	10.00
	South-West	33	20.60

Table 2 Chi square test of independence of categorical variables in relation to the knowledge scores

Variables	Fair (%)	Good (%)	*p* value
Gender			
Female	47 (56.6)	36 (43.4)	**0.016**
Male	28 (36.4)	49 (63.6)	
Marital status			
Married	0 (0.0)	11 (100)	**0.004**
Single	75 (50.3)	74 (49.7)	
Ethnicity			
Others	4 (28.6)	10 (71.4)	0.35
Igbo	46 (47.9)	50 (52.1)	
Yoruba	25 (50.0)	25 (50.0)	
Religion			
Others	5 (83.3)	1 (16.67)	0.83
Christianity	64 (47.4)	71 (52.6)	
Islam	6 (31.6)	13 (68.4)	
School			
University of Lagos	15 (45.5)	18 (54.6)	0.94
University of Nigeria	53 (47.8)	58 (52.3)	
University of Port Harcourt	7 (43.8)	9 (56.3)	
Class opinion			
500 level	24 (55.8)	19 (44.2)	0.23
600 level	51 (43.6)	66 (56.4)	
Geopolitical Zone			
south-east	53 (47.8)	58 (52.3)	0.94
south-west	15 (45.5)	18 (54.6)	
south-south	7 (43.8)	9 (56.3)	

Table 3 Chi square test of independence of categorical variables in relation to the attitude scores

Variables	Fair (%)	Good (%)	*p* value
Gender			
Female	25 (30.1)	58 (69.9)	0.40
Male	29 (37.7)	48 (62.3)	
Marital status			
Married	0 (0.0)	11 (100.0)	**0.034**
Single	54 (36.2)	95 (63.8)	
Ethnicity			
Others	2 (14.3)	12 (85.7)	0.13
Igbo	31 (32.3)	65 (67.7)	
Yoruba	21 (42.0)	29 (58.0)	
Religion			
Others	3 (50.0)	3 (50.0)	0.68
Christianity	45 (33.3)	90 (66.7)	
Islam	6 (31.6)	13 (68.4)	
School			
University of Lagos	9 (27.3)	24 (72.7)	0.22
University of Nigeria	42 (37.8)	69 (62.3)	
University of Port Harcourt	3 (18.8)	13 (81.3)	
Class			
500 level	11 (25.6)	32 (74.4)	0.26
600 level	43 (36.8)	74 (63.3)	
Geopolitical Zone			
South-east	12 (28.6)	30 (71.4)	0.52
South-west	42 (35.6)	76 (64.4)	
South-south			

Regarding academic level, 117 participants were in the 600 level, while 43 were in the 500 level. The distribution of religion among the participants showed that 135 (84.38%) identified as Christians, 19 (11.88%) as Muslims, and 6 (3.75%) as belonging to other religions (Table 1).

Knowledge, attitude and opinion scores

The study categorized the Knowledge, Attitude, and Opinion scores into Good, Fair, and Poor, however, no participant was seen to score poorly in the three parameters assessed (Tables 2, 3 and 4).

In terms of gender differences, male participants scored higher than female participants in knowledge, attitudes, and opinions towards antimicrobial stewardship (supplementary file).

Participants from minority ethnic groups had better opinions, higher knowledge, and more positive attitudes towards antimicrobial stewardship compared to the major ethnic groups.

On analysing performance by religion, participants who identified as Muslims had higher knowledge, better opinions, and more positive attitudes towards antimicrobial stewardship compared to their peers, while Christian participants ranked next, and individuals from other religions had the lowest knowledge scores and less favourable opinions and attitudes (Supplementary file). It

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Table 4 Chi square test of independence of categorical variables in relation to the opinion scores

Variables	Fair (%)	Good (%)	*p* value
Gender			0.32
Female	51 (61.45)	32 (38.55)	
Male	54 (70.13)	23 (29.87)	
Marital status			
Married	5 (45.45)	6 (54.55)	0.26
Single	100 (67.11)	49 (32.89)	
Ethnicity			
Others	6 (42.86)	8 (57.14)	0.13
Igbo	67 (69.79)	29 (30.21)	
Yoruba	32 (64.00)	18 (36.00)	
Religion			
Others	5 (83.33)	1 (16.67)	0.51
Christianity	89 (65.93)	46 (34.07)	
Islam	11 (57.89)	8 (42.11)	
School			
University of Lagos	21 (63.64)	12 (36.36)	0.91
University of Nigeria	74 (66.67)	37 (33.33)	
University of Port Harcourt	10 (62.50)	6 (37.50)	
Class opinion			
500 level	29 (67.44)	14 (32.56)	0.91
600 level	76 (64.96)	41 (35.04)	
Geopolitical Zone			
South-east	74 (66.67)	37 (33.33)	0.91
South-west	21 (63.64)	12 (36.36)	
South-south	10 (62.5)	6 (37.5)	

was also found that there were no significant differences in mean scores between the 500 level and 600 level participants however participants in the 600 level had higher scores compared to those in the 500 level. On analysing performance by school (as shown in supplementary file), the students from University of Port Harcourt had the highest mean opinion score, while the students from University of Lagos had the highest mean knowledge and attitude scores.

Correlation and association of scores and categorical variables

A statistically significant positive correlation was observed between opinion and knowledge scores ($p = 0.0001$) as represented in Fig. 1. Furthermore, a highly statistically significant positive correlation was found between knowledge and attitude scores ($p < 0.001$), as illustrated in Fig. 2. In contrast, age was found to have a statistically significant negative correlation with opinion scores ($p = 0.030$), as shown in Fig. 3.

Chi-square tests revealed that no categorical variable showed a significant relationship with participants' opinions on antimicrobial stewardship (Table 2). However, gender ($p = 0.016$) and marital status ($p = 0.004$) showed significant relationships with participants' knowledge (Table 3), and marital status ($p = 0.034$) showed a

relationship with participants' attitudes towards antimicrobial stewardship (Table 4).

Multivariate regression analysis revealed that the male gender was significantly related to opinions on antimicrobial stewardship. The male gender, single marital status, 600 level or from a minority ethnic group was significantly related to knowledge of antimicrobial stewardship while being single was significantly related to attitudes towards antimicrobial stewardship (Table 5).

Discussion

This study presents a comprehensive evaluation of dental students' knowledge, attitudes, and opinions concerning antimicrobial stewardship (AMS), revealing meaningful variations across demographic subgroups. The findings contribute significantly to the discourse on how educational, cultural, and social determinants shape readiness for antimicrobial stewardship among future healthcare professionals.

Our results demonstrated that male participants, single individuals, and those from minority ethnic backgrounds consistently scored higher in knowledge and attitudes toward AMS. These observations are congruent with previous findings by Abbo et al. (2013), who reported gender-based disparities in AMS knowledge among medical trainees in the United States, noting higher engagement and awareness among male participants [6]. Similarly, Rzewuska et al. (2019) highlighted that cultural and societal contexts significantly affect perceptions of antimicrobial use and resistance, a pattern observed in our study through ethnic and religious differences in AMS competencies [23]. Males may have had more exposure to AMS education or training, or cultural factors might influence their engagement with scientific discussions. Single individuals might have more time or resources to devote to learning about AMS, or they may prioritize education and career development differently [24].

The strong correlation between knowledge and attitudes observed in this study aligns with findings from previous studies as they emphasized that improved knowledge is a key driver of favourable attitudes and prudent prescribing behaviour among dental students [5, 6, 17, 25], however, this differed from a study in two different locations where participants' knowledge did not translate in their attitudes, this we believe is due to the different variables analysed which differs from our own study tool and variables [26, 27]. This finding reinforces the pedagogical principle that foundational knowledge serves as a catalyst for behavioural change, particularly in antimicrobial prescribing and stewardship practices and therefore emphasizes the importance of enhancing knowledge among individuals to promote positive attitudes and opinions related to antimicrobial stewardship.
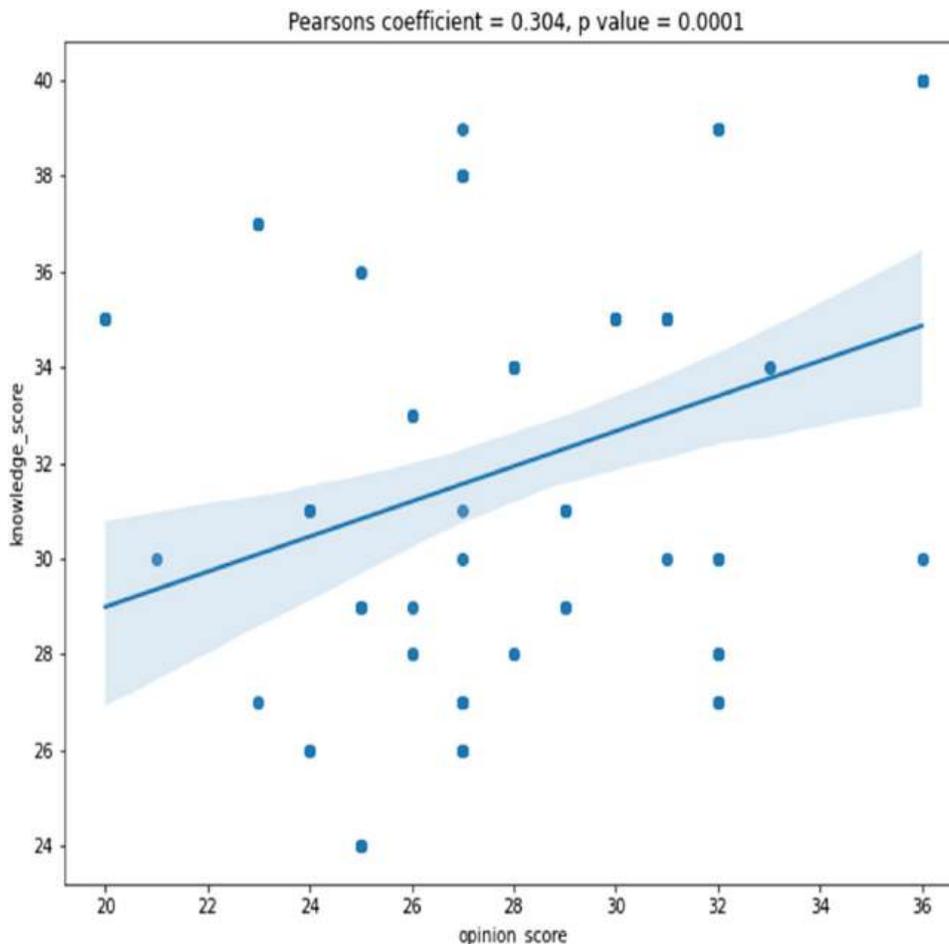
Fig. 1 Positive correlation between Knowledge and Opinion scores among participants

In contrast, age was found to have a statistically significant negative correlation with opinion scores, implying that older individuals tended to have less favourable opinions ($p = 0.030$). This aligns with existing literature indicating that older individuals may exhibit less favourable opinions and/or attitudes toward AMS [28]..

For instance, a study conducted in Ethiopia found that age was significantly associated with medical interns' attitudes and perceptions about AMS. Specifically, younger interns demonstrated more positive attitudes compared to their older counterparts. This suggests that younger medical professionals may be more receptive to AMS principles, possibly due to recent educational exposure or greater adaptability to evolving medical practices [29].

Marital status was also found to be significantly associated with both knowledge and attitude scores. This may suggest that married students, possibly due to increased responsibility or maturity, exhibit more conscientious attitudes towards AMS principles. Further research is warranted to explore this observation.

Unlike some studies that suggest final-year medical students have greater AMS knowledge due to curricular exposure [30], our study found only slight differences between students in later years (500 and 600 levels). This implies that increased clinical exposure doesn't necessarily lead to a deeper understanding of AMS, possibly due to inconsistent integration of stewardship concepts into the curriculum.

However, participants in the 600 level demonstrated higher knowledge and attitude scores. This is similar to the findings of Hu et al., 2018 [17] and Dyarr et al., 2014 [5], thus suggesting that as students progress in their academic journey, their knowledge and attitudes towards antimicrobial stewardship improve. This can be attributed to the fact that final year dental students spend more time in the clinic during rotations and so have more experience on antibiotics administration and principles guiding its use.

Institutional differences were also prominent, with participants from the University of Nigeria scoring significantly lower in knowledge compared to peers from the University of Lagos and University of Port Harcourt. This aligns with earlier findings by Pulcini et al. (2015) [30], who noted that AMS education is inconsistently
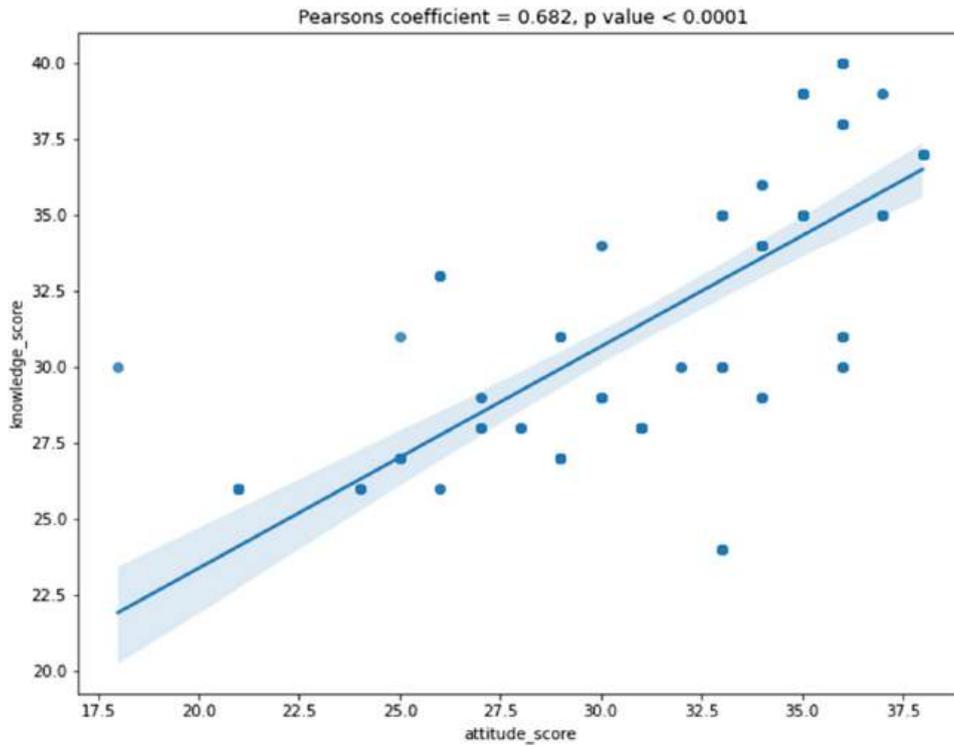
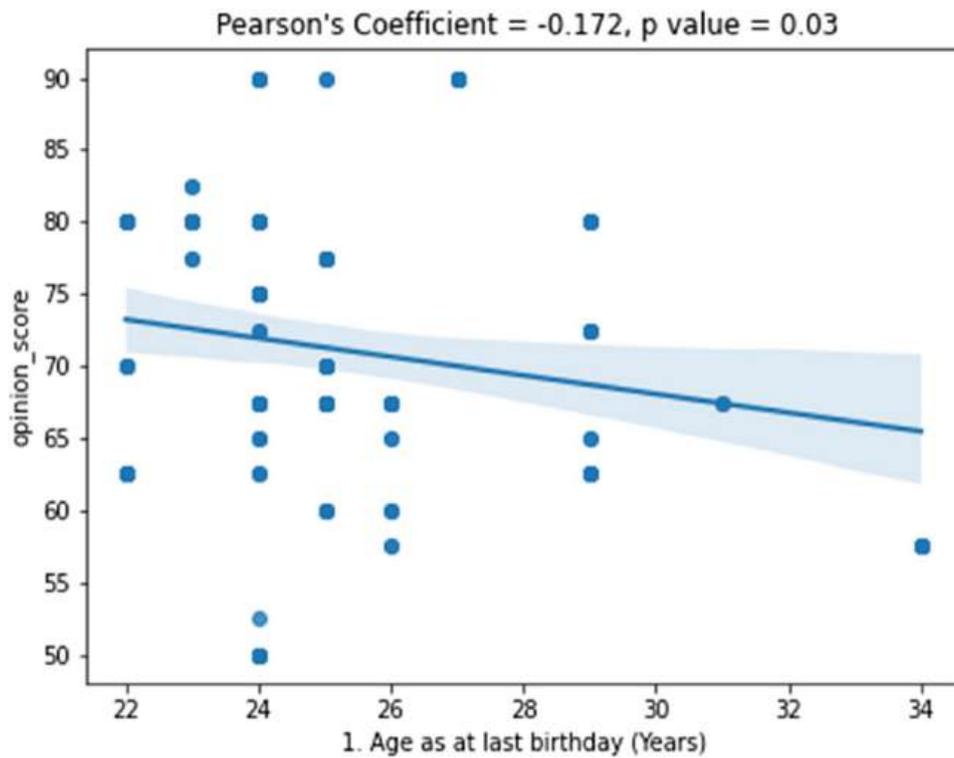**Fig. 2** Strong correlation between the knowledge and attitude scores of the participants

Fig. 3 Negative correlation between opinion score and age

Table 5 Multivariate logistic regression analysis of the demographic variables in relation to the Attitude, knowledge and opinion scores

VARIABLES		ATTITUDE SCORES		KNOWLEDGE SCORES		OPINION SCORES	
Categories		Coeff	*p* value	Coeff	*p* value	Coeff	*p* value
Gender							
	Female	1(R)		1(R)		1(R)	
	Male	1.061	0.147	2.15	**0.004**	1.58	**0.02**
Marital status							
	Married	1(R)		1(R)		1(R)	
	Single	−6.13	**< 0.001**	−6.71	**< 0.001**	−1.33	0.35
Ethnicity							
	Igbo	1(R)		1(R)		1(R)	
	Yoruba	−0.3435	0.677	−0.21	0.797	0.3756	0.62
	Others	2.38	0.065	3.102	**0.016**	2.07	0.08
Religion							
	Christianity	1(R)		1(R)		1(R)	
	Islam	−1.52	0.214	−1.45	0.232	0.229	0.84
	Others	−2.72	0.13	−4.05	**0.02**	−2.03	0.22
School							
	University of Lagos	1(R)		1(R)		1(R)	
	University of Nigeria	−1.085	0.218	−0.014	0.987	−0.4504	0.58
	University of Port Harcourt	0.104	0.937	0.121	0.926	0.0146	0.99
Class opinion							
	500 level	1(R)		1(R)		1(R)	
	600 level	−0.881	0.33	1.76	**0.05**	−1.112	0.18

Note: Outcome variables were dichotomized into Good vs. Fair/Poor. Binary logistic regression was used with 'Good' as the reference outcome

embedded across medical schools, both in content depth and teaching methodology. These findings suggest that educational institutions may play a role in shaping students' knowledge, attitudes, and opinions towards antimicrobial stewardship [31, 32]. Therefore, addressing these disparities such as those related to AMS knowledge and practices, may require national curricular reforms and quality assurance processes to ensure equity in AMS education.

Our study suggests that religion may play a role in shaping AMS knowledge and attitudes, with Muslim participants showing higher performance. This could be linked to broader value systems and health-seeking behaviours, warranting further qualitative exploration. While demographic factors like age, gender, and education level have been studied in relation to AMS knowledge, attitudes, and practices (KAP), the specific impact of religion remains understudied [32, 33]. Existing research often focuses on education and socioeconomic factors, overlooking the potential influence of religious affiliations on AMS KAP.

Given this gap in the literature, our study's findings suggest a novel area for further research. Understanding how religious beliefs and affiliations impact AMS-related knowledge and behaviors could inform the development of culturally sensitive educational interventions and public health strategies.

Strengths and limitations

One of the notable strengths of this study lies in its comprehensive examination of antimicrobial stewardship (AMS) knowledge, attitudes, and opinions across a diverse medical student population. By integrating demographic variables such as gender, age, ethnicity, religious affiliation, level of study, and institutional affiliation, the study offers a multidimensional analysis that goes beyond standard knowledge-attitude-practice (KAP) assessments. The study's methodological rigor is enhanced by the structured scoring system that accounts for both the correctness and the certainty of responses, distinguishing it from more simplistic Likert-scale assessments. Moreover, the application of multivariate statistical analyses—including chi-square tests and regression modeling—adds depth to the interpretation of the findings. These approaches enable the identification of independent predictors of AMS competencies, lending credibility to the observed associations.

Nevertheless, this study is not without limitations. First, the cross-sectional design restricts causal inference. Although associations can be observed, such as the finding that male and Muslim students tend to exhibit higher AMS scores, it is not possible to determine whether these demographic characteristics directly influence stewardship outcomes or whether they are proxies for other unmeasured variables, such as exposure to targeted

educational interventions or cultural norms around medication use.

Second, the self-reported nature of the data introduces potential bias. Participants may have overestimated their knowledge or selected socially desirable responses, especially on items assessing attitudes and opinions. Although the scoring system attempted to mitigate this by weighting responses based on confidence and correctness, social desirability bias cannot be fully ruled out.

Third, the study was confined to students from three Nigerian universities, which may limit the generalizability of findings to other regions or countries with different educational systems, sociocultural dynamics, or AMS infrastructures. Additionally, while the study explored an under-researched variable, religion, it lacked qualitative follow-up that might explain why religious affiliation impacts AMS competencies. This restricts the interpretive power of the findings and suggests the need for more in-depth, mixed-methods research.

Recommendations

To address the variability in antimicrobial stewardship (AMS) knowledge among medical students, it's essential to implement standardized AMS modules across medical curricula nationwide. These modules should be introduced early in medical training and reinforced throughout, ensuring a consistent and comprehensive understanding of AMS principles.

Targeted interventions are also necessary to support underperforming groups, including female students, students from majority ethnic groups, and older students. Educational approaches that are gender-sensitive, culturally inclusive, and age-appropriate can help bridge the knowledge gaps and promote more effective learning.

Future research should incorporate qualitative methods, such as focus groups or interviews, to gain a deeper understanding of the factors influencing AMS knowledge and attitudes, particularly in relation to religion and cultural identity. This will enable the development of culturally competent AMS strategies that cater to diverse needs.

Moreover, future studies should aim to include a broader range of institutions across different regions and employ longitudinal designs to track changes in knowledge and attitudes over time. This will enhance the generalizability of findings and provide valuable insights into the effectiveness of AMS education.

Finally, the findings from such studies should be translated into practical applications through partnerships with health ministries and public health agencies. By collaborating with these stakeholders, it's possible to develop nationwide AMS policies and educational campaigns that address the growing threat of antimicrobial resistance.

Conclusion

This study provides valuable insight into the antimicrobial stewardship (AMS) competencies of dental students across multiple institutions, highlighting significant associations between demographic factors and AMS-related knowledge, attitudes, and opinions. These findings underscore the influence of sociocultural and educational contexts on students' engagement with antimicrobial stewardship principles.

While the overall awareness and attitudes toward AMS among participants were encouraging, the disparities identified call for a more nuanced, inclusive approach to medical education. Approaches include nationwide standardization of AMS curricula, integration of stewardship modules early in clinical training, gender-sensitive and culturally adapted teaching strategies, and periodic assessment of prescribing competencies. All these are essential to ensure that all future healthcare professionals are equally equipped to combat antimicrobial resistance.

In advancing AMS education, there lies a critical opportunity to not only strengthen individual competencies but also to cultivate a new generation of prescribers capable of making informed, ethical, and globally responsible decisions in antimicrobial use. Future research should continue to explore these dynamics, employing mixed-methods and longitudinal designs to deepen our understanding and enhance the impact of educational interventions.

Abbreviations
AMS	Antimicrobial Stewardship
AMR	Antimicrobial Resistance
COMREC	College of Medicine Research Ethics Committee
CI	Confidence Interval
KAP	Knowledge, Attitudes, and Practices
OR	Odds Ratio
p-value	Probability Value
SD	Standard Deviation
SPSS	Statistical Product and Service Solutions
WHO	World Health Organization

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12909-025-08182-8.

Supplementary Material 1.

Declarations

Ethics approval and consent to participate
Ethical approval was obtained from the College of Medicine Research Ethics Committee (COMREC) of the University of Nigeria with the protocol no NHREC/COMREC/0158/03/2023. Prior to participation, all individuals provided written informed consent, confirming their comprehension of the study's objectives, methods, and potential risks. Participation was entirely voluntary, and individuals reserved the right to withdraw at any stage without penalty or consequence. To ensure confidentiality, all collected data were securely stored in anonymized systems, adhering to the ethical standards outlined in the Declaration of Helsinki for human subject research.

Consent for publication
A written informed consent was obtained from all participants.

Competing interests
The authors declare no competing interests.

Contributions
OPU conceptualized the study. EAA supervised the study. All authors were involved in data collection. CC analyzed the data. All authors wrote the first and final drafts. All authors read and approved the final manuscript.

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