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Research Article

Knowledge and Perception of AMR and AMS Among Undergraduate Health Students at UDUS, Nigeria

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Abstract

Background: Antimicrobial resistance (AMR) is a major global public health threat driven largely by inappropriate antimicrobial use and inadequate stewardship. Antimicrobial stewardship (AMS) promotes optimal antimicrobial prescribing to limit resistance. As future prescribers and healthcare providers, undergraduate health students play a critical role in AMR containment; however, evidence regarding their preparedness in Nigeria remains limited. *Objective:* To assess the knowledge and perceptions of AMR and AMS among final-year undergraduate students in selected health-related faculties at Usmanu Danfodiyo University, Sokoto (UDUS), Nigeria. *Methods:* A descriptive cross-sectional study was conducted between September and November 2025 among final-year students in Medicine (MBBS), Pharmacy, Nursing Science, Medical Laboratory Science (MLS), and Veterinary Medicine. Using proportionate stratified random sampling, 235 students were recruited from 431 eligible students. Data were collected using a structured, self-administered questionnaire adapted from validated instruments. AMR and AMS knowledge were each scored out of 7 and categorized as poor (0–3), average (4–5), or good (6–7). Data were analyzed using SPSS version 20 with descriptive statistics and chi-square tests. Statistical significance was set at $p < 0.05$. *Results:* Overall, 84.7% of respondents demonstrated good knowledge of AMR, while 78.3% demonstrated good knowledge of AMS. Knowledge differed significantly by course of study for both AMR ($\chi^2 = 46.33$, $p < 0.001$) and AMS ($\chi^2 = 28.70$, $p < 0.001$), with MBBS and Pharmacy students outperforming Nursing students. Despite high levels of knowledge, important misconceptions persisted, including a misunderstanding of resistance mechanisms and support for non-prescription access to antibiotics (57.9%). A majority reported limited formal AMS training within the curriculum (70.6%), yet over 90% expressed a desire for more education on AMR and AMS. *Conclusion:* Although final-year health students demonstrated satisfactory baseline knowledge of AMR and AMS, significant conceptual gaps and permissive attitudes toward inappropriate antibiotic use remain. Strengthening structured, interprofessional AMS education within undergraduate curricula is urgently needed to prepare future healthcare professionals for effective antimicrobial stewardship in Nigeria.

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Antimicrobial Resistance (AMR), Antimicrobial Stewardship (AMS), Health Students, Sub-Saharan Africa, Nigeria, Knowledge and Perception

1. Introduction

Antimicrobial resistance (AMR) has emerged as a significant global health threat and is increasingly regarded as a silent pandemic. It contributes to substantial morbidity, mortality, and rising healthcare expenditures, affecting both hospital-acquired and community-acquired infections [1]. By 2050, AMR is estimated to cause major global economic losses, particularly in low- and middle-income countries (LMICs), if effective containment strategies are not implemented [1, 2]. Several factors contribute to the rise of AMR, including weak regulatory systems, poor awareness of appropriate antimicrobial practices, online access to medications, and the overuse, misuse, or incorrect dosing of antimicrobials in both humans and animals [3-5]. This problem is especially pronounced in many low-income settings where antibiotics can often be purchased over the counter without a prescription [6]. Given this growing threat, future healthcare professionals must receive adequate training to promote rational antimicrobial use. Strengthening the education and training of healthcare workers, including medical students, on appropriate antibiotic prescribing is therefore considered an essential component of AMR containment efforts [7].

In response to the escalating threat of AMR, the World Health Organization (WHO) World Health Assembly endorsed a global action plan on antibiotic resistance in 2015. This plan outlines several key objectives, including enhancing awareness and understanding of AMR through effective communication, education, and training; strengthening the evidence base through improved surveillance and research systems; and ensuring the rational use of antimicrobials in both human and animal health [7].

Antimicrobial stewardship (AMS) represents a core strategy within this global response. It encompasses coordinated interventions designed to promote the optimal selection, dosing, and duration of antimicrobial therapy to achieve the best possible clinical outcomes while reducing unnecessary exposure and the development of resistance [7, 8]. The overarching aim of AMS is to ensure patient safety and preserve the effectiveness of existing antimicrobial agents. Healthcare professionals, including students currently undergoing training, therefore play a critical role in addressing the expanding challenge of AMR [8, 9].

Education and training of healthcare workers and students on antimicrobial stewardship (AMS) have been recognised as essential components of efforts to contain AMR [3, 9, 10]. Although several countries have incorporated teaching on the appropriate use of antimicrobials into student curricula and continuing professional development programmes, evidence regarding the depth, consistency, and effectiveness of such training among healthcare students in Nigeria remains limited [11].

Despite growing global emphasis on integrating AMR and AMS competencies into undergraduate health curricula, there is a paucity of institution-specific data from Nigerian universities evaluating students' knowledge levels, misconceptions, and perceptions toward stewardship practices. Without such evidence, curriculum reform and policy alignment with national AMR containment strategies may lack empirical direction. Therefore, this study aimed to assess the knowledge and perception of undergraduate students regarding antimicrobial resistance and antimicrobial stewardship within selected health-related faculties at Usmanu Danfodiyo University, Sokoto.

2. Methodology

2.1. Study Design

A descriptive cross-sectional study was conducted between September and November 2025 among final-year undergraduate students in selected health-related faculties at Usmanu Danfodiyo University, Sokoto.

2.2. Study Population and Sample Size

The study population comprised only final-year students in Medicine (MBBS), Pharmacy, Nursing Science, Medical Laboratory Science (MLS), and Veterinary Medicine. The total eligible population was 431 (MBBS = 126; Pharmacy = 94; Nursing = 54; MLS = 92; Veterinary Medicine = 65) students. Sample size was determined using Yamane's formula at a 5% precision level, yielding a minimum of 208 participants (MBBS = 61, Pharmacy = 45, Nursing = 26, MLS = 44, Veterinary Medicine = 31). A total of 235 students were recruited and analyzed, with 27 additional participants included due to higher voluntary response rates from MBBS (extra 19), pharmacy (extra 2), and Nursing (extra 6) students during data collection, while maintaining proportionate allocation within strata where possible. All participants were in their final year of study: 500 level for Pharmacy, Nursing Science, Medical

Laboratory Science, and Veterinary Medicine; 600 level for MBBS.

2.3. Sampling Technique

Students were stratified by course of study, and proportionate allocation was applied based on departmental population sizes. Within each stratum, students were randomly invited to participate via Google Forms links sent through class representatives, ensuring equal opportunity for selection.

2.4. Data Collection Instrument and Procedure

Data were collected using a structured, self-administered questionnaire adapted from previously validated instruments [11, 13, 14]. The questionnaire comprised five sections: (1) demographics, (2) knowledge of antimicrobial resistance (AMR), (3) knowledge of antimicrobial stewardship (AMS), (4) perceptions of AMS interventions, and (5) self-assessment of curriculum adequacy. Although no formal pilot testing was conducted because the questionnaire was adapted from previously tested and established instruments [13, 14], the instrument underwent content validity review by two infectious disease experts. Post-hoc assessment of internal consistency yielded Cronbach's alpha values of 0.72 for the AMR knowledge section and 0.68 for the AMS knowledge section, indicating acceptable reliability for an exploratory study. A hybrid administration approach was employed, paper-based and online (via Google Forms), to maximize participation and accessibility. No notable differences in response patterns were observed between the two modes (data not shown).

2.5. Variables and Outcome Measures

The primary outcome variables were knowledge of AMR and knowledge of AMS, each scored out of 7 (based on correct responses to 7 items per section). One point was assigned for each correct response and 0 for incorrect or unsure responses. Total scores ranged from 0–7 and were categorized as: Poor: 0–3; Average: 4–5, and Good: 6–7. Independent variables included age, gender, course of study, and level of study.

2.6. Data Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 20. Descriptive statistics (frequencies and percentages) were used to summarize demographic characteristics, knowledge responses, perceptions, and self-assessment items. Knowledge scores for AMR and AMS were computed by assigning 1 point for each correct response and 0 for incorrect or unsure responses. Chi-square tests were applied to examine associations between course of study (and level of study where relevant) and knowledge categories (poor, average, good), with statistical significance set at $p < 0.05$.

2.7. Ethical Considerations

Ethical approval was obtained from the Usmanu Danfodiyo University Sokoto Health Research Ethics Committee. Participation was voluntary, informed consent was obtained, and data were collected anonymously.

3. Results

3.1. Demographic Characteristics of the Respondents

A total of 235 final-year undergraduate students participated in the study. The majority were aged 20–25 years (56.6%), and males constituted over two-thirds of respondents (68.9%). Medicine and Surgery (MBBS) students formed the largest proportion by course of study (34.0%, n=80), followed by Pharmacy (20.0%, n=47), Medical Laboratory Science (18.7%, n=44), Nursing Science (14.0%, n=33), and Veterinary Medicine (13.2%, n=31). Most participants were at 500 level (73.6%), with MBBS students at 600 level constituting the remaining 26.4%. Full demographic details are presented in Table 1.

Table 1. *Demographic characteristics of final-year undergraduate health students participating in the study at Usmanu Danfodiyo University, Sokoto, Nigeria (n=235), showing distribution by age, gender, course of study, and academic level.*

Statements/Items		Frequency	Percentage
Age	20-25	133	56.6
	26-30	102	43.4
	Total	235	100.0
Gender	Male	162	68.9
	Female	73	31.1
	Total	235	100.0

Statements/Items		Frequency	Percentage
Course of Study	Medical Laboratory Science	44	18.7
	Medicine and Surgery	80	34.0
	Nursing	33	14.0
	Pharmacy	47	20.0
	Veterinary Medicine	31	13.2
	Total	235	100.0
Level	500	173	73.6
	600	62	26.4
	Total	235	100.0

3.2. Knowledge of Antimicrobial Resistance

Overall, knowledge of AMR was high across most items. Nearly all respondents correctly identified the existence of multiple antibiotic classes (98.8%) and that antibiotics can disrupt normal bacterial flora (86.4%). A majority correctly rejected premature cessation of antibiotics (74.0%) and the superiority of broad-spectrum prescribing (61.3%). However, important misconceptions were evident: 61.7% incorrectly agreed that better antibiotic use would have no impact on resistance, and 46.4% endorsed community-level antibiotic prophylaxis for common infections such as typhoid and pneumonia. Notably, 94.5% incorrectly attributed resistance to the human body rather than to bacteria, reflecting a fundamental conceptual gap. These findings are summarised in Table 2 below.

Table 2. *Responses of final-year undergraduate health students to seven items assessing knowledge of antimicrobial resistance (AMR), showing frequency and percentage of True, False, and Unsure responses (n=235), Usmanu Danfodiyo University, Sokoto, Nigeria.*

S/N	Factors	True N, (%)	False N, (%)	Unsure N, (%)
1.	There are many classes of antibiotics	231 (98.8)	4 (1.7)	0 (0)
2.	Antibiotics can kill normal bacterial flora in the body	203 (86.4)	18 (7.7)	14 (6.0)
3.	Better use of antibiotics will not have an impact on antimicrobial resistance	145 (61.7)	76 (32.3)	14 (6.0)
4.	Prescribing broad-spectrum antibiotics is always better, even if narrower-spectrum antibiotics are effective	72 (30.6)	144 (61.3)	19 (8.1)
5.	Antibiotics should be used within the community for prophylaxis of infections like typhoid and pneumonia	109 (46.4)	101 (43.0)	25 (10.6)
6.	Patients should stop taking their antibiotics as soon as they feel better	49 (20.9)	174 (74.0)	12 (5.1)
7.	Antibiotic resistance occurs when the human body becomes resistant to antibiotics, and they no longer work	222 (94.5)	4 (1.7)	9 (3.8)

3.3. Knowledge of Antimicrobial Stewardship

Knowledge of AMS concepts was generally strong, though certain misconceptions persisted. The vast majority of respondents correctly identified that AMS ensures the right patient receives the right antimicrobial at the right time, dose, and route (94.5%), and that pharmacists have a role in AMS (96.6%). Most also correctly recognised that AMS is not restricted to hospital settings (76.6% answered False) and that stewardship is not the sole responsibility of physicians (83.8% answered False). However, 17.9% incorrectly agreed that AMS should only be implemented in hospital settings, and 12.3% believed only doctors should be involved, indicating

residual gaps in understanding the multidisciplinary and community-wide scope of stewardship. Detailed responses are presented in Table 3.

Table 3. *Responses of final-year undergraduate health students to five items assessing knowledge of antimicrobial stewardship (AMS), showing frequency and percentage of True, False, and Unsure responses (n=235), Usmanu Danfodiyo University, Sokoto, Nigeria.*

S/N	Factors	True N, (%)	False N, (%)	Unsure N, (%)
1.	AMS helps to limit the occurrence and spread of antimicrobial resistance globally	204 (86.8)	15 (6.4)	16 (6.8)
2.	AMS ensures the right patient gets the right antimicrobial for the right indication, at the right time, with the right dose, and through the right route	222 (94.5)	4 (1.7)	9 (3.8)
3.	AMS should be implemented only in hospital settings	42 (17.9)	180 (76.6)	13 (5.5)
4.	Only doctors should be involved in antimicrobial stewardship	29 (12.3)	197 (83.8)	9 (3.8)
5.	Pharmacists have a role to play in AMS	227 (96.6)	4 (1.7)	4 (1.7)

3.4. Understanding of AMS Team Composition and Scope

The understanding of AMS team composition and scope was mixed. Regarding team membership, only 49.4% of respondents correctly identified that the AMS team includes all listed cadres (doctors, hospital and community pharmacists, nurses, laboratory scientists, and veterinary doctors) while the remaining respondents attributed stewardship to individual professional groups. Concerning the scope of AMS, 55.7% correctly selected 'all of the above', recognising that AMS encompasses antimicrobial study, appropriate selection, suitable route, and appropriate duration of therapy. These findings are presented in Table 4.

Table 4. *Responses of final-year undergraduate health students on the composition of the antimicrobial stewardship (AMS) team and the scope of AMS practice (n=235), Usmanu Danfodiyo University, Sokoto, Nigeria.*

Area assessed	Options	N, (%)
Members of the AMS team (n = 235)	Doctors	33 (14.0)
	Hospital Pharmacists	15 (6.4)
	Nurses	21 (8.9)
	Community Pharmacists	18 (7.7)
	Laboratory Scientists	20 (8.5)
	Veterinary Doctors	12 (5.1)
	All of the above	116 (49.4)
The scope of AMS includes (n = 235)	The study of antimicrobials	53 (22.6)
	Choosing antimicrobials appropriately	17 (7.2)
	Selecting a suitable route	5 (2.1)
	Choosing appropriate duration	12 (5.1)
	All of the above	131 (55.7)
	All except 'the study of antimicrobials'	17 (7.2)

3.5. Level of Knowledge of AMR and AMS by Course of Study

Knowledge of both AMR and AMS differed significantly across courses of study. For AMR, the proportion of students with good knowledge was highest among MBBS (82.5%) and Pharmacy (97.9%) students, while Nursing students had the lowest rate of good knowledge (48.5%), with 33.3% scoring in the poor category. The difference across courses was statistically significant ($\chi^2 = 46.33$, df = 8, $p < 0.001$), as shown in Table 5. A similar pattern was observed for AMS knowledge: MBBS (86.3%) and Pharmacy (91.5%) students again demonstrated higher rates of good knowledge, while Nursing students had the lowest proportion of good knowledge (51.5%) and the highest proportion of poor knowledge (45.5%). This difference was also statistically significant ($\chi^2 = 28.70$, df = 8, $p < 0.001$), as presented in Table 6.

Table 5. *Distribution of antimicrobial resistance (AMR) knowledge scores by course of study among final-year undergraduate health students at Usmanu Danfodiyo University, Sokoto, Nigeria (n=235), with chi-square test results.*

Course of study	Knowledge					
	Good (6-7)	Average (4-5)	Poor (0-3)	Chi-square	df	P-value
MLS	40	3	1	46.33	8	0.0001
MBBS	66	9	5			
Nursing	16	6	11			
Pharmacy	46	1	0			
Veterinary Medicine	28	1	2			

Table 6. *Distribution of antimicrobial stewardship (AMS) knowledge scores by course of study among final-year undergraduate health students at Usmanu Danfodiyo University, Sokoto, Nigeria (n=235), with chi-square test results.*

Course of study	Knowledge					
	Good (6-7)	Average (4-5)	Poor (0-3)	Chi-square	df	P-value
MLS	37	2	5	28.70	8	0.0001
MBBS	69	2	9			
Nursing	17	1	15			
Pharmacy	43	1	3			
Veterinary Medicine	26	0	5			

3.6. Perceptions of Antimicrobial Stewardship Interventions

Perceptions of AMS interventions revealed a striking disconnect between knowledge and attitudes. A large majority (80.0%) agreed that antibiotics should be obtainable without a prescription, contradicting a core stewardship principle. Most respondents also rejected key stewardship practices: 88.1% disagreed that healthcare professionals require additional training to be effective stewards, 87.2% rejected the role of monitoring and evaluation in AMS, and 86.4% disagreed that cultures and susceptibility testing are essential to AMS. Furthermore, 56.2% agreed that a single antimicrobial dosage is suitable for all population groups, reflecting gaps in understanding of individualised dosing. Perceptions of respondents toward AMS interventions are detailed in Table 7.

Table 7. *Perceptions of final-year undergraduate health students toward antimicrobial stewardship (AMS) interventions, showing frequency and percentage of responses on a five-point Likert scale (Strongly Agree to Strongly Disagree) for seven items (n=235).*

S/N	Statement/Item	SA N, (%)	A N, (%)	N N, (%)	D N, (%)	SD N, (%)
1.	Antibiotics should be obtained without a prescription	136 (57.9)	52 (22.1)	8 (3.4)	17 (7.2)	22 (9.4)
2.	Healthcare professionals require additional training on antimicrobial prescription and use to be effective antimicrobial stewards	15 (6.4)	6 (2.6)	7 (3.0)	82 (34.9)	125 (53.2)
3.	Restricting the use of selected antibiotics will preserve their efficacy and limit resistance	11 (4.7)	12 (5.1)	28 (11.9)	82 (34.9)	102 (43.4)
4.	Pharmaceutical industries contribute to AMS by limiting the advertisement of broad-spectrum antibiotics.	8 (3.4)	27 (11.5)	48 (20.4)	84 (35.7)	68 (28.9)
5.	AMS involves regular updates, reporting, monitoring, and evaluation of antimicrobial use and resistance in a region	4 (1.7)	1 (0.4)	25 (10.6)	80 (34.0)	125 (53.2)
6.	Taking cultures and susceptibility tests are essential to AMS	10 (4.3)	8 (3.4)	14 (6.0)	61 (26.0)	142 (60.4)
7.	A specific dosage of an antimicrobial agent is suitable for all groups of people	62 (26.4)	70 (29.8)	30 (12.8)	42 (17.9)	31 (13.2)

SA = Strongly Agree, A = Agree, N = Neutral, D = Disagree, SD = Strongly Disagree.

3.7. Self-Assessment of Knowledge and Curriculum Adequacy

Self-assessment responses revealed a substantial disconnect between formal training and students' perceived knowledge needs. Only 15.7% of respondents agreed that their university curriculum includes dedicated lectures on AMS, while 70.6% disagreed, suggesting that AMS content is either absent or insufficiently visible within the formal curriculum. Over one-third (35.7%) reported acquiring most of their AMS knowledge from sources outside the university curriculum. Despite this, only approximately one-quarter of students rated their current knowledge of antimicrobials (25.1%) or AMR/AMS (26.4%) as adequate for their future careers. Most notably, over 90% expressed a desire for more education on appropriate antimicrobial use (91.1%), AMR (92.8%), and AMS (94.5%), underscoring a clear and urgent student-driven demand for strengthened curricula. Full self-assessment data are presented in Table 8 below.

Table 8. *Self-assessment of curriculum adequacy and knowledge of antimicrobial resistance (AMR) and antimicrobial stewardship (AMS).*

S/N	Statement/Item	Agree N, (%)	Unsure N, (%)	Disagree N, (%)
1.	Your university's curriculum includes lectures on AMS	37 (15.7)	32 (13.6)	166 (70.6)
2.	You obtained most of your knowledge on AMS via learning materials outside your university curriculum	84 (35.7)	19 (8.1)	132 (56.2)
3.	My current knowledge of antimicrobials is adequate for my future career	59 (25.1)	56 (23.8)	120 (51.1)
4.	My current knowledge of AMR and AMS is adequate for my future career	62 (26.4)	64 (27.2)	109 (46.4)
5.	I would like more education on the appropriate use of antimicrobials	4 (1.7)	17 (7.2)	214 (91.1)
6.	I would like more education on antimicrobial resistance	9 (3.8)	8 (3.4)	218 (92.8)
7.	I would like more education on antimicrobial stewardship	7 (3.0)	6 (2.6)	222 (94.5)

4. Discussion

This study examined the knowledge and perceptions of undergraduate students in health-related faculties at Usmanu Danfodiyo University, Sokoto (UDUS), regarding antimicrobial resistance (AMR) and antimicrobial stewardship (AMS). The findings provide important insights into the preparedness of future healthcare professionals in Nigeria, revealing both encouraging levels of baseline awareness and critical conceptual and practical gaps that require urgent attention through targeted educational and curricular reforms. The respondents demonstrated a reasonable foundational understanding of antimicrobials, particularly in the classification of antibiotic agents, with most students correctly identifying multiple antibiotic classes. This finding is consistent with reports of relatively high baseline AMR awareness among health sciences students in Pakistan and Uganda, where exposure to pharmacology and infectious disease concepts increases familiarity with antibiotic classes [15, 16]. Similar levels of awareness have also been reported among Nigerian and other African undergraduate populations, suggesting that fundamental AMR concepts are being introduced across health-related programs globally [12, 14]. However, despite this foundational knowledge, substantial misconceptions were evident. A notable proportion of students believed that improved antibiotic use would not significantly impact resistance, reflecting a poor understanding of the causal relationship between antimicrobial misuse and the emergence of resistance. Additionally, support for routine community-level antibiotic prophylaxis for common infections suggests inadequate comprehension of appropriate antibiotic indications. These findings mirror reports from Northern Nigeria and other low- and middle-income settings, where inappropriate beliefs about antibiotic use remain prevalent even among health sciences students [12, 14]. One of the most concerning findings was the widespread misconception that antibiotic resistance occurs when the human body becomes resistant to antibiotics rather than bacteria developing resistance mechanisms. This fundamental conceptual error has been repeatedly documented in studies among undergraduate students in Pakistan, Uganda, and other regions [15, 16]. The persistence of this misunderstanding represents a critical educational gap with serious implications for future prescribing behavior and patient counseling. Healthcare professionals who lack a clear understanding of microbial resistance mechanisms may be less effective in educating patients on adherence to antibiotic regimens and the public health consequences of misuse. With respect to antimicrobial stewardship, students demonstrated variable levels of understanding. While most respondents correctly recognized the role of AMS in limiting antimicrobial resistance and promoting appropriate prescribing, misconceptions regarding its scope and implementation were evident. Some students perceived AMS as applicable only within hospital settings or as the sole responsibility of physicians, which contradicts the World Health Organization's emphasis on AMS as a multidisciplinary, system-wide intervention involving physicians, pharmacists, nurses, microbiologists, and public health professionals. Similar limitations in AMS comprehension have been reported among undergraduate students in Pakistan and Saudi Arabia, where familiarity with the term "antimicrobial stewardship" did not translate into a deep understanding of its principles or collaborative nature [15]. Findings among pharmacy students and recent graduates in the International Pharmaceutical Students Federation (IPSF) have similarly shown gaps between perceived and actual AMS knowledge [13]. Although overall knowledge scores were satisfactory, agreement with statements supporting non-prescription antibiotic access and uniform dosing across populations indicates persistent misconceptions in practical stewardship application [13, 15]. Encouragingly, the recognition of pharmacists' roles in stewardship among UDUS respondents aligns with findings among Nigerian pharmacy students and reflects growing awareness of pharmacists as key AMS stakeholders [12] and IPSF pharmacy students/recent graduates [13]. The coexistence of relatively strong conceptual knowledge and permissive attitudes toward non-prescription antibiotic access suggests that knowledge alone may be insufficient to influence prescribing-related beliefs in settings where non-regulated antibiotic access is socially normalized. Support for obtaining antibiotics without a prescription was common, directly contradicting evidence-based stewardship principles [13]. This finding is particularly alarming in the Nigerian context, where over-the-counter access to antibiotics remains widespread despite regulatory restrictions, and has been consistently reported in Nigerian and regional studies [10, 14]. Such attitudes underscore the risk that future healthcare professionals may inadvertently perpetuate inappropriate antibiotic practices if these beliefs are not addressed during training. The analysis further demonstrated statistically significant differences in knowledge across courses of study, with medical and pharmacy students exhibiting higher knowledge scores than nursing students. This disparity likely reflects differences in curriculum depth, particularly in pharmacology, microbiology, and infectious disease training. Similar disciplinary differences have been reported in Pakistan and other settings, where pharmacy and medical students consistently outperform nursing students in AMR and AMS knowledge assessments [15, 16]. The comparatively lower knowledge among nursing students is concerning, given their central role in antimicrobial administration, infection prevention, and patient education. A striking disconnect was observed between students' self-assessment of curricular exposure and their demonstrated knowledge. Few respondents reported receiving formal AMS lectures, yet moderate knowledge was evident in certain domains, suggesting that stewardship concepts may be embedded within other courses rather than delivered as distinct instructional units. More than half of the students reported acquiring AMS knowledge from sources outside the formal curriculum, highlighting the role of self-directed learning and informal information channels. Importantly, an overwhelming majority expressed a desire for

additional education on antimicrobial use, resistance, and stewardship, providing a clear mandate for curriculum strengthening. These findings have significant educational implications. There is an urgent need for comprehensive and clearly defined AMS modules within undergraduate health curricula, with explicit emphasis on the biological mechanisms of resistance, rational prescribing, and interprofessional collaboration. Curriculum reforms should aim to standardize core AMR and AMS competencies across all health disciplines to address observed knowledge disparities. Incorporating interprofessional education may further enhance students' understanding of complementary professional roles in stewardship activities.

4.1. Strengths and Limitations

The strengths of this study include its comprehensive assessment of AMR and AMS knowledge across multiple health-related faculties, contributing valuable data to the limited Nigerian literature in this area. However, the findings should be interpreted in light of certain limitations, including the single-institution design, which may limit generalizability beyond Usmanu Danfodiyo University; UDUS is a federal university located in Northwestern Nigeria, and its curriculum structure, student demographics, institutional resources, and exposure to infectious disease training may differ from those of private or other regional universities in Nigeria, potentially limiting national representativeness; the cross-sectional nature, capturing knowledge at one time point without assessing retention or behavior change; reliance on self-reported responses, which may introduce social desirability or recall bias (particularly for curriculum exposure); students may have overestimated their knowledge or provided responses they perceived as professionally appropriate, thereby introducing response bias and potentially inflating knowledge or perception estimates; absence of pilot testing, though content validity was supported by expert review; and lack of multivariable analysis to fully control for confounders such as age, gender, or prior exposure.

4.2. Conclusion

While undergraduate students demonstrated satisfactory baseline knowledge of AMR and AMS, important misconceptions regarding resistance mechanisms and antibiotic access, as well as curricular deficiencies, persist. Significant differences across disciplines further highlight inconsistencies in training exposure among health-related programs. These findings underscore the need for comprehensive and standardized AMR and AMS education across undergraduate curricula.

We recommend the integration of structured AMS modules across all health faculties, the incorporation of interprofessional stewardship training and simulation-based learning, and closer alignment of university curricula with Nigeria's National Action Plan on Antimicrobial Resistance. Strengthening undergraduate education in this manner is essential to equip future healthcare professionals with the competencies required for effective antimicrobial stewardship and sustainable AMR containment.

Abbreviations

AMR	Antimicrobial Resistance
AMS	Antimicrobial Stewardship
UDUS	Usmanu Danfodiyo University, Sokoto
MBBS	Bachelor of Medicine, Bachelor of Surgery
MLS	Medical Laboratory Science
LMICs	Low- and Middle-Income Countries
SPSS	Statistical Package for the Social Sciences
WHO	World Health Organization

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Author Contributions

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Conflicts of Interest

The authors declare no conflicts of interest.

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