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# Patterns of Antimicrobial Use, Access, and Stewardship Awareness Among Clinical Medical and Dental Students at the University of Nigeria, Enugu Campus (UNEC)

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## Abstract

# Background

Antimicrobial resistance (AMR) is a major public health concern in low- and middle-income countries such as Nigeria, worsened by self-medication and poor stewardship expectations among future healthcare givers, reinforcing the challenge. This study investigated antimicrobial use patterns, misuse behaviours and awareness of stewardship among clinical medical and dental students with the aim of supporting the implementation of specific interventions.

# Methods

A cross-sectional online survey was conducted between January and February 2026. The structured questionnaire assessed data on demographics, knowledge of antimicrobials (6-point rating scale), recent use (last 12 months), indicators of misuse (such as starting treatment without a prescription and not completing the course of treatment), and exposure to stewardship. After exclusions, 237 responses were analysed using Python for descriptives, chi-square/t-tests, Spearman correlations, logistic regression, and exploratory clustering/factor analysis. Misuse was defined as a composite binary outcome.

# Results

The mean age was 22.3 years (SD 1.9), male 54%, clinical sciences 92%. The knowledge score was 5.15/6 (SD 1.02) with deficiencies observed in empiric therapy (65% correct). Recent antibiotic use was 66% (mean 2.5 courses), mostly for respiratory (31%) and malaria-like symptoms (18%), with 70% having no diagnostics. Non-prescription use was 40%, and incomplete course was 35%. Behaviours were correlated (for example, sharing-keeping leftovers, $\rho = 0.45$ for $\rho = 0.57$). No significant determinants of misuse were found (e.g. male OR = 1.25, 95% CI 0.74–2.11, $p = 0.40$). Seventy-four per cent (mostly 1–2 hours) received stewardship instruction; 36% (more in clinical years, $p < 0.001$) were aware of guidelines. Clustering revealed high-misuse profiles; 76% expressed training interest.

# Conclusions

Although knowledge was adequate, students in Nigeria commonly misused antimicrobials; this was influenced by self-medication and limited stewardship exposure. The integration of diagnostics and AMS education in the curriculum could reduce risks and be in line with the national AMR plans.

## Introduction

Antimicrobial resistance (AMR) is a significant and rapidly growing threat to global health, potentially making common infections untreatable and undermining decades of advances in modern medicine. The World Health Organisation (WHO) reports alarming global resistance patterns in common bacterial pathogens and advocates for immediate measures concerning stewardship, surveillance, and infection control (1). There is evidence that a misuse and overuse of antibiotics in both community and clinical settings, including the unauthorised widespread non-prescription access, are major contributors to this phenomenon. Taking account of this issue, WHO has recently convened a global consultation and is raising awareness through campaigns, calling for the elimination of over-the-counter (OTC) antibiotic sales, noting that OTC availability is widespread in many contexts where formal healthcare delivery is scarce and constitutes a significant barrier to stewardship (2, 3).

An apparently unrecognised and unacknowledged way in which antibiotics are overused in many malaria-endemic and resource-poor regions is through their empirical use for febrile illness. Coinciding clinical syndromes in malaria, bacterial, and viral disease, in combination with the lack of robust point-of-care diagnostics, have led to widespread empiric antibiotic use and community self-medication for febrile illness. East African cohort and facility studies also document high rates of antibiotic use for children with undifferentiated fever and routine empiric antibiotic provision when malaria tests are negative, providing evidence that management of febrile illness promotes antibiotic exposure in these communities (4, 5).

The burden of AMR in sub-Saharan African (SSA) countries is worsened by fragile regulatory mechanisms, inadequate diagnostic infrastructure, insufficient antimicrobial stewardship (AMS), and a large informal medicine market. Recent regional reviews and WHO-region analyses report high rates of resistance for key pathogens and emphasise that community acquisition of antibiotics without prescription, poor quality of medicines, and weak and inconsistent stewardship implementations are prevalent problems in SSA. These systemic determinants propagate an enabling environment that encourages misuse of antimicrobials and is difficult to reverse without harmonised One-Health and holistic-systems interventions (6).

Nigeria exemplifies these continental challenges at the national level. The Nigeria Centre for Disease Control (NCDC) and national action plans highlight the widespread availability of antibiotics without prescription, the absence of adequate public understanding, and the continued burden of misuse in community and health institutions (7). Multiple cross-sectional surveys and field studies in Nigeria report that a significant percentage of the populace and health-care seekers use antibiotics without prescription, with community pharmacies and patent medicine vendors providing one of the nearest, if not the nearest, access to antibiotics. These care seeking behaivours in combination with variable stewardship implementation in health facilities, make Nigeria an urgent priority for targeted interventions in undergraduate education and health-system policy (7, 8). Also, recent narrative and systematic reviews report the wide-scale resistance among clinical isolates, the ubiquitous inappropriate prescribing, and the significant challenges to the implementation of stewardship in human, animal, and environmental sectors, all indicating that Nigeria is long overdue for a One-Health approach (9).

A particularly significant driver of inappropriate antibiotic use in many parts of Nigeria is the management of febrile illness, including presumptive malaria with antibiotics, a practice rooted in lack of diagnostic certainty and in cultural beliefs that fever is malaria or "typhoid." Reporting and surveillance summaries, along with studies by region, confirm that antibiotics are frequently used in self-treatment of febrile illness, even though they have no effect on the causative organism of malaria; this behaviour further increases unnecessary exposure of the population to antibiotics (10,11).

Undergraduate clinical medical and dental students represent a key target group for AMR control. As soon-to-be prescribers, they form the next generation of clinicians whose habits and attitudes will shape institutional prescribing culture. Personal antibiotic use behaviours (self-medication, sourcing OTC) and lack of knowledge about institutional prescribing guidelines across training may translate into prescribing attitudes and practices in early clinical practice, potentially perpetuating inappropriate antibiotic use. Many Nigerian and regional studies show that AMR awareness is high among the student population, but these studies also reveal persistent knowledge gaps and widespread self-medication, indicating that undergraduate education, by itself, has not consistently led to stewardship-aligned behaviours (8, 12). There are relatively few focused, high-resolution evaluations of clinical year medical and dental students at hospital-based campuses in the south-eastern Nigeria (UNTH-Enugu campus/UNEC), contexts where students integrate community exposures with clinical postings and have frequent access to prescribing clinicians.

Hence, this cross-sectional study targets clinical medical and dental students of the University of Nigeria Teaching Hospital (UNTH) Enugu Campus with threefold objectives: (i) to evaluate knowledge and attitudes towards antibiotics and AMR, (ii) to report recent behaviour with regard to personal use of antibiotics and obtaining access to such drugs (including sources and whether use followed a prescription); and (iii) to identify and measure awareness of institutional antibiotic-prescribing policies or receipt of AMS training. Secondary aims are to investigate student-level predictors (age, year of clinical training, previous AMS instruction) of non-prescription antibiotic access and low stewardship awareness. We hypothesise that a significant number of clinical students indicate non-prescription antibiotic access and poor knowledge of prescribing guidelines, and that higher seniority and previous AMS instruction will predict superior knowledge and reduced likelihood of self-medication.

## Methods

# Study design and setting

This was a cross-sectional study performed among clinical medical and dental students in a single Nigerian medical institution in Nigeria. It was administered online, data was collected between January and February, and participants were in all years of clinical dental and medical education (400-, 500-, and 600-level). Participation was voluntary and anonymous. No personally identifying details were collected. Sample size n was calculated for a misuse prevalence of 50% (most conservative estimate based on Nigerian-related studies), 5% margin of error and 95% CI, making the number of respondents 385; however, we were able to get 237 due to time constraints, adequate for descriptives (power > 80% for medium effect size). The final version of the questionnaire was administered in English. The full questionnaire is provided as Supplementary File 1.

## Study population and eligibility

All clinical, medical and dental students enrolled during the study period were eligible for inclusion. Inclusion criteria were: (1) being a student in the Faculty of Clinical Sciences or Dentistry, (2) the student was willing to participate, and (3) the student had attended at least one clinical rotation. Those who did not consent to participate or returned incomplete questionnaires were excluded from the analysis. The survey was distributed through WhatsApp groups.

## Data collection instrument

A structured self-administered questionnaire was developed to evaluate antibiotic use, knowledge of antimicrobial stewardship (AMS), exposure to formal AMS education, and attitudes towards antibiotic use (12, 13).

The instrument consisted of items on sociodemographic and academic characteristics (such as age, sex, faculty, academic level, and clinical rotations attended), self-reported recent use of antibiotics in the past 12 months, number of antibiotic courses taken, adherence to prescribed courses, sources of antibiotics, indications for use, self-medication practices (such as sharing, incomplete courses, keeping leftovers, non-prescribed initiation, malaria-related use), and knowledge and awareness of antimicrobial resistance and stewardship in a self-reported manner (such as formal teaching received, duration, sources of learning, participation in stewardship activities, awareness of hospital guidelines, and willingness to attend additional training).

Participants were unequivocally told not to use any external resources, including search engines or large language models, while filling out the survey, and to answer the questions based on their personal experience, and that it was acceptable to say I don't know or to be uncertain.

## Data management and preparation

A total of 239 responses were obtained. We included 237 responses in the analysis; two participants did not consent to participate. Data were cleaned and preprocessed using Python (pandas, numpy, scipy.stats):

- Missing data: Mainly because of logical skips for participants who are non-users of antibiotics; coded as "Not Applicable."
- Outliers: Age over the 95th percentile (> 26 years) was truncated, and extreme self-reported antibiotic use (> 6 courses/year) was truncated to minimise skewness.

- Derived variables: knowledge score (sum of correct answers to six knowledge items, 0–6). Misuse binary (described as reporting of the following: starting antibiotic course without prescription, incomplete course, sharing antibiotics, frequent use for malaria, always retaining leftovers, or often/always purchasing without prescription. Teaching hours (ordinal coding; none = 0, 1–2 = 1, 3–5 = 2, > 5 = 3). Level group (pre-clinical: 400-level vs. clinical: levels 500–600).
- We "exploded" all multiselect fields (rotations, sources of learning) to enable frequency analysis.

### Outcome definitions

The key outcome was misuse of antimicrobial agents, defined by a composite binary indicator that captured at least one of the following behaviours: non-adherence to prescribed antibiotic courses and self-medication with antibiotics, either without a prescription or for non-bacterial and/or inappropriate indications. Secondary outcomes included AMS knowledge scores and trends in antibiotic access and use

## Statistical analysis

Analyses were conducted in Python 3.12 (pandas 2.0, numpy 1.26, scipy 1.11, scikit-learn 1.3 for clustering). Data were analysed by descriptive and inferential statistics. Categorical variables were presented as frequencies and percentages, and continuous variables as mean and standard deviation or median and interquartile range as relevant. Associations between misuse of antimicrobial agents and participant characteristics were evaluated by chi-square tests or categorical variables and independent t-tests for continuous variables, or where cells were small, Fisher's exact test. We assessed correlations between scores of AMS knowledge and variables related to educational exposure through appropriate correlation coefficients. Analyses were two-sided, and the level of statistical significance was set at $p < 0.05$.

Logistic regression was used to model predictors of antimicrobial misuse (knowledge score, academic level and sex). The odds ratios (ORs) with 95% confidence intervals (CIs) were reported. Relationships between the ordinal variables and misuse behaviours (e.g. sharing, use of leftovers, purchase without prescription) were evaluated with Spearman rank correlations.

### Additional and exploratory analyses

Exploratory analyses were also performed to thoroughly characterise patterns of misuse and stewardship awareness. Stratified descriptive analyses were conducted by age group and exposure to clinical rotations, examining co-occurring misuse behaviour and thematic categorisation of indications for use of antibiotics as reported, and exploratory cluster analysis of respondents based on misuse and knowledge profile. We considered these analyses as hypothesis-generating and were interpreted descriptively. Three clusters (elbow method) were used for the k-means clustering procedure; exploratory factor analysis was performed using varimax rotation.

### Sensitivity and robustness checks

Limited sensitivity analyses were conducted to examine the robustness of key descriptive estimates. To mitigate the effect of outliers, the highest value of the number of reported courses of antibiotics was truncated at > 6 courses; inspection of non-truncated values did not result in material changes in the overall prevalence of antimicrobial overuse. "I can't remember" responses to the question about finishing an antibiotic course were reclassified as unfinished courses, with little effect on the predicted proportion of misuse. Also, bootstrap resampling (1,000 iterations) was conducted with respect to the mean number of courses of antibiotics in users, in order to assess stability of the estimate, providing a 95% confidence interval of 1.54–2.23. The purpose of these checks was to establish that the descriptive results were robust, not to re-estimate inferential models.

## Ethical considerations

The study followed the Declaration of Helsinki principles, and ethical approval was obtained from the University of Nigeria ethics committee. Participation was voluntary, informed consent was implied by survey completion, and all responses were collected anonymously.

### Results

## Participant characteristics

After excluding non-consenting entries, a total of 237 (99.2%) respondents were included in the final analysis; of the 239 received responses. The mean age of the participants was 22.3 years (SD 1.9), with an age range from 18 to 26 years. Just over half of the respondents were male at 54.4%, and the remaining 45.6% were female.

Most of the participants were from the Faculty of Clinical Science (91.6%), with a smaller number of participants enrolled in the Faculty of Dentistry (8.4%). Respondents were spread across clinical training levels (400-, 500-, and 600-level), with most in senior clinical years. Table 1 summarises the sociodemographic and academic characteristics of the included respondents.

Table 1
Sociodemographic and Academic Characteristics of Respondents (N = 237)

| Characteristic | n (%) or Mean ± SD |
|---|---|
| **Age (years)** | 22.3 ± 1.9 |
| Age range | 18–26 |
| **Sex** | |
| Male | 129 (54.4) |
| Female | 108 (45.6) |
| **Faculty** | |
| Clinical Sciences | 217 (91.6) |
| Dentistry | 20 (8.4) |
| **Academic level** | |
| 400 level | 62 (26.2) |
| 500 level | 114 (48.5) |
| 600 level | 61 (25.3) |

Table 2 summarises the distribution of attended clinical rotations among the respondents.

Table 2
Distribution of Attended Clinical Rotations Among Respondents

| Clinical rotation | Number of mentions* | Percentage (%) |
|---|---|---|
| Internal Medicine | 91 | 15.3 |
| Surgery | 89 | 15.0 |
| Obstetrics & Gynaecology | 68 | 11.5 |
| Paediatrics | 67 | 11.4 |
| Ophthalmology | 58 | 9.8 |
| Dermatology | 56 | 9.4 |
| Psychiatry | 52 | 8.8 |
| Family Medicine | 51 | 8.7 |
| Community Medicine | 31 | 6.2 |
| Other rotations† | < 10 each | < 1.0 each |

** Multiple responses allowed; percentages are calculated as a proportion of total rotation mentions, not total respondents.*

*† Includes infrequently reported, each contributing < 1%, and consolidated for clarity.*

## Knowledge of antimicrobials and antimicrobial resistance

Overall knowledge of antimicrobials and AMR was high among respondents. The average knowledge score was 5.15 ± 1.02 (out of a maximum of 6), while the 95% confidence interval for the mean knowledge score was 5.02–5.28. The majority of the respondents were correctly aware of the principles guiding appropriate use of antimicrobials, de-escalation, drivers of resistance, and stewardship. However, fewer correct answers were given for questions evaluating understanding of empiric antimicrobial therapy (64.6%) and on the suitable duration for antibiotic treatment (78.1%), and these two were the least correctly answered items. Table 3 highlights the distribution of correct responses to antimicrobial and antimicrobial resistance knowledge items among clinical medical and dental students.

Table 3
Knowledge of Antimicrobials and Antimicrobial Resistance Among Respondents (N = 237)

| Knowledge item | Correct response | n (%) correct |
|---|---|---|
| Appropriate use of antibiotics | Antibiotics should be used only when indicated for bacterial infections | 229 (96.6) |
| Empiric antimicrobial therapy | Initiation based on likely pathogens before culture results | 153 (64.6) |
| Reason for de-escalation | To reduce resistance and toxicity once pathogen is identified | 226 (95.4) |
| Appropriate duration of therapy | Use for the recommended duration only | 185 (78.1) |
| Major contributor to antimicrobial resistance | Inappropriate and excessive antibiotic use | 207 (87.3) |
| Core principle of antimicrobial stewardship | Optimising antibiotic choice, dose, and duration | 220 (92.8) |
| **Knowledge score (0–6)** | Mean ± SD | **5.15 ± 1.02** |

## Personal antimicrobial use in the past 12 months

About two-thirds of the respondents (65.8%) had used antibiotics in the past 12 months. The average number of courses of antibiotics was 2.5 over the recall period among those who had taken antibiotics. The most frequently cited reasons for current use of antibiotics were respiratory symptoms and illnesses associated with malaria, but a large number of patients had taken antibiotics without any testing for diagnosis before the start of treatment. Hospital or clinic pharmacies were the most common source of antibiotics (50%), followed by patent medicine vendors (30%) and leftover medications (10%). Table 4 summarises the prevalence, frequency, indications, and diagnostic practices related to recent antimicrobial use among clinical medical and dental students.

Table 4
Patterns of Recent Antimicrobial Use Among Respondents (N = 237)

| Variable | n (%) or Mean ± SD |
|---|---|
| **Antibiotic use in past 12 months** | |
| Yes | 156 (65.8) |
| No | 81 (34.2) |
| **Number of antibiotic courses*** | |
| Mean ± SD | 2.5 ± 1.4 |
| **Main reason for most recent antibiotic use*** | |
| Respiratory symptoms | 49 (31.4) |
| Suspected malaria | 28 (17.9) |
| Diarrheal illness | 21 (13.5) |
| Fever of unknown cause | 14 (9.0) |
| Urinary symptoms | 11 (7.1) |
| Other indications | 33 (21.1) |
| **Diagnostic testing prior to antibiotic use*** | |
| None | 109 (69.9) |
| Malaria test only | 16 (10.3) |
| Culture or sensitivity testing | 15 (9.6) |
| Other tests | 16 (10.2) |

**Among respondents who reported antibiotic use in the past 12 months (n = 156).*

## Antimicrobial access and self-medication practices

Among those who took antibiotics within the last 12 months, 59.6% initiated antibiotic use following a prescription, while the rest reported non-prescription initiation. Completion of the full prescribed course of antibiotics was reported by only 60.3% of users. Behaviours linked to misuse of antibiotics or other antimicrobials, such as sharing antibiotics with others, retaining leftover drugs for future use, and obtaining antibiotics without a prescription, were frequently reported. A few respondents also reported having taken antibiotics for a malaria-related illness.

Using a composite definition, 35% of all respondents met criteria for antimicrobial misuse. The 95% confidence interval for the overall misuse prevalence was 29.0%–41.3%. Despite these behaviours, 94.9% acknowledged that non-prescription antibiotic use increases antimicrobial resistance. Table 5 highlights patterns of antimicrobial access and self-medication behaviours among respondents who reported antibiotic use in the past 12 months.

Table 5
Antimicrobial Access and Use Behaviours Among Antibiotic Users (n = 156)

| Behavior | n (%) |
|---|---|
| **Initiated antibiotics with prescription** | 93 (59.6) |
| **Completed full antibiotic course** | 94 (60.3) |
| **Purchased antibiotics without prescription (often/always)** | 20 (12.8) |
| **Shared antibiotics with others** | 28 (17.9) |
| **Kept leftover antibiotics for future use (always)** | 26 (16.7) |
| **Used antibiotics for malaria-related illness** | 28 (17.9) |

## Antimicrobial stewardship awareness and training exposure

The majority of the respondents reported having received some form of formal teaching on antimicrobial stewardship (74.3%), although there was a wide variation in the reported lengths of training. Exposure to teaching was most frequently constrained to 1 to 2 hours; only 15.0% reported receiving more than five hours of training; meanwhile, over twenty per cent of respondents reported having received no formal teaching on stewardship. Lectures were reported as the most frequently cited learning source, followed by self-study and ward-based learning.

Awareness of hospital antibiotic prescribing guidelines was reported by 36.3% of respondents, and involvement with antimicrobial stewardship activities was limited. Among the respondents, there was a high level of willingness for further antimicrobial stewardship training. Table 6 summarises antimicrobial stewardship training exposure, awareness, and preferences among the respondents.

Table 6
Antimicrobial Stewardship Training and Awareness Among Respondents (N = 237)

| Variable | n (%) |
|---|---|
| **Received formal AMS teaching** | |
| Yes | 176 (74.3) |
| No | 61 (25.7) |
| **Duration of AMS teaching** | |
| None | 52 (22.1) |
| 1–2 hours | 103 (43.4) |
| 3–5 hours | 46 (19.5) |
| >5 hours | 36 (15.0) |
| **Aware of hospital antibiotic prescribing guidelines** | 86 (36.3) |
| **Participated in AMS-related activities** | 25 (10.5) |
| **Willingness to attend additional AMS training** | |
| Definitely | 85 (35.9) |
| Probably | 95 (40.1) |
| Maybe | 47 (19.8) |
| Unlikely/No | 10 (4.2) |
| **Preferred training formats*** | |
| Online self-paced learning | 71 (30.0) |
| Short workshops | 59 (24.9) |
| Case-based learning | 47 (19.8) |
| Other formats | 60 (25.3) |

**Multiple responses allowed.*

## Factors associated with antimicrobial misuse

Inappropriate use of antimicrobials was defined as reporting any of the following behaviours: using antibiotics with no prescription, interrupting the antibiotic course, sharing antibiotics with other people, frequently using antibiotics for malaria-related illness, purchasing antibiotics without prescription

(often/always), or keeping leftover antibiotics for future use (always). Applying this definition, nearly 35% of the participants qualified for antimicrobial misuse. Table 7 captures the bivariate associations between respondent characteristics and antimicrobial misuse.

Table 7
Bivariate Associations Between Respondent Characteristics and Antimicrobial Misuse (N = 237)

| Variable | Misuse (%) | No misuse (%) | Test statistic | p-value |
|---|---|---|---|---|
| **Sex** | | | $\chi^2 = 0.77$ | 0.38 |
| Male | 46.5 | 53.5 | | |
| Female | 43.5 | 56.5 | | |
| **Faculty** | | | $\chi^2 = 0.41$ | 0.52 |
| Clinical Sciences | 45.4 | 54.6 | | |
| Dentistry | 40.0 | 60.0 | | |
| **Academic level** | | | $\chi^2 = 1.12$ | 0.29 |
| Pre-clinical | 48.0 | 52.0 | | |
| Clinical | 44.2 | 55.8 | | |
| **Knowledge score (mean ± SD)** | 5.10 ± 1.04 | 5.20 ± 1.01 | t = 0.32 | 0.75 |
| **Formal AMS teaching** | | | $\chi^2 = 1.36$ | 0.24 |
| Yes | 43.8 | 56.2 | | |
| No | 49.2 | 50.8 | | |

On bivariate analysis, misuse of antimicrobials was not significantly associated with sex, faculty, academic year, or mean score of knowledge. But knowledge of hospital antibiotic prescribing protocols was much higher among students in senior clinical years than pre-clinical students ($\chi^2 = 14.41$, $p < 0.001$). In multivariable logistic regression, none of the examined predictors independently predicted antimicrobial misuse. Table 8 highlights the multivariable logistic regression analysis of factors associated with antimicrobial misuse.

Table 8
Multivariable Logistic Regression Analysis of Predictors of Antimicrobial Misuse (N = 237)

| Predictor | Adjusted OR | 95% CI | p-value |
|---|---|---|---|
| Knowledge score | 0.93 | 0.71–1.22 | 0.58 |
| Pre-clinical level (vs. clinical) | 0.74 | 0.39–1.39 | 0.34 |
| Male sex (vs. female) | 1.25 | 0.74–2.11 | 0.40 |

## Additional analyses

Inappropriate use of antimicrobials varied slightly by age and by the number of clinical rotations completed. Rates of misuse of 51.1% and 41.7% were observed among participants aged 21 years and 18–20 years, respectively. Analysis of rotations revealed higher misuse among respondents who had attended Paediatrics (53.2%) and Family Medicine (55.6%) rotations compared to those who had not, suggesting exposure to diverse cases may not directly reduce personal misuse. Misuse prevalence was lower among respondents who received > 5 hours of AMS teaching (38.9%) compared to those with no teaching (49.0%). These results are summarised in Tables 9a and 9b, respectively.

Table 9
a. Antimicrobial Misuse by Age Group (N = 237)

| Age group (years) | % Misuse |
|---|---|
| 18–20 | 41.7 |
| 21 | 51.1 |
| ≥ 22 | 46.5 |

Table 9
b. Misuse by Completed Clinical Rotations (N = 237)

| Rotation | % Misuse (Completed) | % Misuse (Not Completed) |
|---|---|---|
| Internal Medicine | 47.6 | 45.0 |
| Surgery | 44.8 | 48.2 |
| Paediatrics | 53.2 | 42.0 |
| Obstetrics & Gynaecology | 52.6 | 42.3 |
| Psychiatry | 53.4 | 43.3 |
| Dermatology | 48.7 | 45.3 |
| Ophthalmology | 50.6 | 44.2 |
| Family Medicine | 55.6 | 42.4 |
| Community Medicine | 52.9 | 44.6 |

Furthermore, the number of formal AMS teaching hours received and knowledge scores of the respondents were positively correlated (Spearman $\rho = 0.23$, $p < 0.001$), showing that greater exposure to teaching was associated with higher antimicrobial knowledge. Knowledge scores declined modestly over the survey collection period (early respondents: 5.46; late respondents: 4.88.

Spearman correlation analysis also showed strong positive correlations among some misuse behaviours. Sharing antibiotics was correlated with keeping leftovers ($\rho = 0.45$) and buying without a prescription ($\rho = 0.41$). Keeping leftovers and buying without a prescription were also correlated ($\rho = 0.33$), showing the clustering of behaviours related to misuse of antimicrobials. Spearman correlations between misuse practices are highlighted in Table 9c.

Table 9
c. Spearman Correlations Between Misuse Behaviours (N = 156)

| Behavior | Purchase_No_Prescription | Sharing | Keep_Leftovers | Frequent_Malaria_Use |
|---|---|---|---|---|
| Purchase_No_Prescription | 1.00 | 0.41 | 0.33 | 0.17 |
| Sharing | 0.41 | 1.00 | 0.45 | 0.19 |
| Keep_Leftovers | 0.33 | 0.45 | 1.00 | 0.13 |
| Frequent_Malaria_Use | 0.17 | 0.19 | 0.13 | 1.00 |

The cluster analysis on the misuse behaviours revealed three profiles: “High-Misuse Frequent Users” (Cluster 0), “Low-Misuse Non-Users” (Cluster 1), and “High-Misuse Self-Medicators” (Cluster 2). Factor analysis identified two latent dimensions: Factor 1 (Misuse Propensity) and Factor 2 (Frequency vs Social Misuse), reflecting trends in sharing, storing leftovers, and non-prescribed initiation. These analyses could guide targeted interventions. Table 9d highlights the behaviour clusters of antibiotic use and misuse, while Table 9e summarises the factor loadings for antimicrobial misuse behaviours

Table 9
d. Behavioural Clusters of Antibiotic Use and Misuse (N = 156)

| Cluster | N | Misuse_Binary | Times_Used | Non_Prescribed_Start | Incomplete_Course | Sharing | Purchase_No_Prescription | Keep_Leftove |
|---|---|---|---|---|---|---|---|---|
| 0 | 75 | 1.00 | 3.36 | 0.61 | 0.44 | 0.52 | 0.00 | 0.23 |
| 1 | 142 | 0.11 | 0.79 | 0.00 | 0.67 | 0.00 | 0.00 | 0.00 |
| 2 | 20 | 1.00 | 3.90 | 0.80 | 0.75 | 0.80 | 1.00 | 0.45 |

Table 9
e. Factor Loadings for Antimicrobial Misuse Behaviours (N = 156)

| Behavior | Factor1 (Misuse Propensity) | Factor2 (Frequency vs Social Misuse) |
|---|---|---|
| Misuse_Binary | 0.88 | 0.11 |
| Times_Used | 0.47 | 0.25 |
| Non_Prescribed_Start | 0.69 | 0.31 |
| Incomplete_Course | -0.08 | -0.12 |
| Sharing | 0.70 | -0.37 |
| Purchase_No_Prescription | 0.46 | -0.18 |
| Keep_Leftovers | 0.46 | -0.39 |

## Sensitivity and robustness checks

To investigate the stability of key descriptive results, limited sensitivity analyses were performed. To reduce the effect of outliers, extreme values for the number of reported courses of antibiotics were truncated (> 6 courses); the use of uncapped values did not lead to any major changes in the prevalence of antimicrobial misuse overall. Also, answers indicating “I can’t remember” with regard to course completion were recoded as incomplete courses, which had no impact on the estimated prevalence of misuse. Bootstrap resampling (1,000 iterations) was applied to the mean number of antibiotic courses, and was used to assess the precision of self-reported antibiotic use, yielding a 95% confidence interval of 1.54–2.23. These checks indicate that the primary descriptive estimates are not driven by extreme values or missing response handling.

## Discussion

# Interpretation of key findings

Our findings illustrate a paradox for Nigerian clinical medical and dental students: excellent knowledge of antimicrobial stewardship (mean score 5.15/6) coexists with widespread inappropriate usage (35%); lower than national averages (50–80%) (14), including 40% non-prescribed initiations and 50% not completing their course of antibiotics. Such a gap between knowledge and practices emphasises that cognitive awareness alone is not enough for translation to prudent antimicrobial practices, potentially worsened by contextual factors such as the ease of access to over-the-counter antibiotics without prescription in Nigeria. The 66% recent antibiotic use, driven by respiratory and malaria-like symptoms, in the absence of diagnostics (70%), is reflective of infectious disease workloads in resource-limited areas, and also identifies gaps in diagnostics. A clustering procedure revealed high misuse profiles (e.g., high frequency of self-medicators), indicating targeted subgroups for interventions. Exposure to stewardship training (74%) was limited (predominantly 1 to 2 hours); and was positively correlated with knowledge scores, interest was high (76%), reporting a window of opportunity to educate in the face of low guideline awareness (36%), especially among pre-clinical students.

# Comparison with existing literature

These results align with findings from recent studies conducted among African students on student behaviours to use antimicrobials. The rate of self-medication (40%) is comparable to those reported amongst healthcare students in Tanzania (49.1%) (15) and Eritrea (59.1%) (16), but lower than the general estimates for the Nigerian populace (46.5–71.9%) (17), but it is higher than desired, given that that respondents had educational exposure (18). Misuse of malaria drugs (18%) is in line with regional trends, where presumptive treatment undermines the susceptibility of the parasite in the absence of rapid diagnostics (19). Deficits in empiric therapy (65% correct) mirror Tanzanian medical students' deficiencies (20), and the positive associations between teaching hours and knowledge ($\rho = 0.23$) support identified interventions seen in Afghanistan (post-education AMR awareness increase) and Zambian hospital surveys (21,22). Factor and behaviour cluster analyses also support KAP findings in a review of 28 African countries, where dispensing healthcare workers (HCWs) also exhibited comparable knowledge-attitude discrepancies (71% good knowledge, 42% good practices) (23). In contrast to some studies associating male sex or non-medical disciplines with increased misuse, no predictors were identified from our regressions, perhaps attributable to uniform clinical training of the cohort (24,25).

# Strengths and limitations

The multifocal analysis (descriptives, regressions, clustering) of this study offers a detailed understanding of student behaviour, and sensitivity checks support the robustness of the results (e.g., bootstrapped CI for courses: 1.54–2.23). The sample was large (N = 237) from a prominent Nigerian university, making the findings more generalizable to the West African context. Limitations of this study include the probability of self-report bias potentially leading to an underestimation of inappropriate use, and a cross-sectional nature of the study, precluding the establishment of causality, as well as a single-site focus, which may limit generalizability amid Africa's diverse healthcare systems. Recall bias for 12-month use and truncated outliers may influence precision, though checks mitigated this (26). Despite these limitations, our study adds to the increasing body of literature on antibiotic use and stewardship among prospective healthcare professionals in Nigeria.

# Implications for education and policy

The findings support the incorporation of comprehensive AMS in curricula with an emphasis on empiric therapy and diagnostics using the appropriate channels (online/short workshops) (27, 28). Student-led projects, such as Students Against Superbugs Africa (29), could help raise awareness, while policy needs to enforce restrictions on OTC and dissemination of guidelines to fill pre-clinical voids (30). Providing interventions in the form of an app or virtual communities, especially targeting high-misuse clusters, may help promote behaviour change (31). Ultimately, in line with the WHO African Region targets, this could contribute to reducing the projected 10 million AMR deaths in 2050 (32).

# Future directions

Follow-up studies monitoring prescribing practices following graduation, multi-site comparisons across Africa, and intervention trials (e.g. app-based AMS) are warranted (33). The assessment of the community empowerment models, as in Rwanda, could yield insights to inform scalable strategies (34). Further study is needed to investigate the longitudinal assessment of curricular improvements and multistrategy interventions that encompass education, behavioural science, and policy to advance antimicrobial stewardship.

## Conclusions

Nigerian clinical medical and dental students demonstrated good theoretical knowledge of antimicrobials, but inappropriate use of antibiotics was still prevalent among them; thus, highlighting a persistent knowledge–behaviour gap. Formal AMS education was associated with better knowledge, but did not consistently translate into responsible practices. Behavioural profiles reflect diverse misuse patterns necessitating targeted interventions. Enhancing

longitudinal stewardship education, providing better diagnostic support, and addressing structural drivers such as non-prescription access are critical to reduce inappropriate antibiotic use among future prescribers.

## Abbreviations

- **AMR**
Antimicrobial Resistance
- **AMS**
Antimicrobial Stewardship
- **CI**
Confidence Interval
- **IQR**
Interquartile Range
- **KAP**
Knowledge, Attitudes, and Practices
- **OR**
Odds Ratio
- **SD**
Standard Deviation
- **SSA**
Sub–Saharan Africa
- **WHO**
World Health Organisation

## Declarations

# Ethics approval and consent to participate

All applicants provided informed consent for the use of their anonymised data for research purposes. Ethical review and exemption or approval were obtained from the Ethics Committee of the University of Nigeria Teaching Hospital (NHREC/05/01/2008B-FW00002458-1RB00002513). All approaches conformed to the Declaration of Helsinki and the Nigerian National Code of Health Research Ethics before analysis. All data were maintained in compliance with institutional guidelines for confidentiality and data security.

**Consent for publication**

Not applicable. No individual person's data are presented in this manuscript.

**Competing interests**

The authors declare that they have no competing interests. All authors confirm that they have no affiliations with, or involvement in, any organization or entity with any financial interest (such as honoraria, educational grants, participation in speakers' bureaus, membership, employment, consultancies, stock ownership, patent-licensing arrangements, or expert testimony) or non-financial interest (such as personal or professional relationships, affiliations, knowledge, or beliefs) that could be perceived to influence the content of this manuscript.

# Clinical trial number

Not applicable.

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# Author Contribution

Godswill Uzoechina (GU) conceptualised the study, designed the analysis plan, performed the data analysis, and drafted the Results and Discussion sections. GU also coordinated overall manuscript preparation, supervised the project, and critically revised all sections for intellectual content. Elochukwu Marvellous (EM), Anthony Nwuba (AN), Victoria Lemeh (VL), and Nneka Uzochukwu (NU) managed data collection and contributed to the development of the study instruments. Treasure Osajiuba (TO) drafted the Methods and Abstract section, EM drafted the Introduction and Conclusion. All authors reviewed, edited, and approved the final manuscript and agree to be accountable for all aspects of the work.

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Not applicable

## Data Availability

The datasets generated and analyzed during this study contain sensitive information about individual participants and are therefore not publicly available. Access to the data can be granted by the corresponding author upon reasonable request, subject to approval by the institutional ethics committee to ensure compliance with participant confidentiality and ethical guidelines.

## References

1. World Health Organisation. Antimicrobial resistance. Geneva, World Health Organisation. : 2023 Nov 21. Available from: https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance
2. World Health Organisation. Global campaign to phase out over-the-counter (OTC) antibiotic sales: consultation report. Geneva: World Health Organisation. 2024 Jul 15. Available from: https://www.who.int/publications/m/item/global-campaign-to-phase-out-over-the-counter-(otc)-antibiotic-sales-consultation-report
3. World Health Organisation. Report on the global consultation on the campaign to phase out over-the-counter (OTC) antibiotic sales. Geneva: World Health Organisation. 2024 Jul. 48 p. Available from: https://cdn.who.int/media/docs/default-source/antimicrobial-resistance/amr-gcp-asa/report_antibiotics-campaign_web.pdf
4. Hooft AM, Ndenga B, Mutuku F, Otuka V, Ronga C, Chebii PK, et al. High frequency of antibiotic prescription in children with undifferentiated febrile illness in Kenya. Clin Infect Dis. 2021;73(7):e2399–406. 10.1093/cid/ciaa1305. PMID: 32882032; PMCID: PMC8492150.
5. Kitpreechavanich S, Sribenjalux P, Sribenjalux S. Antimicrobial stewardship in tropical infectious diseases: focusing on dengue and malaria. Trop Med Infect Dis., Gahimbare L, Muvunyi CM, Guessennd NAK, Rutanga JP, Gashema P, Fuller W et al. Antimicrobial resistance in the WHO African region: a systematic literature review 2016–2020. Antibiotics. 2024;13(7):659. doi: 10.3390/antibiotics13070659. PMID: 39061341; PMCID: PMC11274714.
6. Nigeria Centre for Disease Control. What is antimicrobial resistance (AMR)? Abuja: NCDC. 2023 Apr 6. Available from: https://ncdc.gov.ng/diseases/factsheet/70
7. Gladys OU, Gabriella CN, Lawal FO, Bukola FO, Amaechi VC, Augustine ON. Antibiotics stewardship: prevalence, nature, and factors associated with dispensing of antibiotics without prescription among community pharmacists in Nigeria. J Pharm Policy Pract. 2025;18(1):2498927. 10.1080/20523211.2025.2498927. PMID: 40336878; PMCID: PMC12057783. 9. Alabi ED, Rabiu AG, Adesoji AT. A review of antimicrobial resistance challenges in Nigeria: the need for a one health approach. One Health. 2025;20:101053. doi: 10.1016/j.onehlt.2025.101053. PMID: 40370425; PMCID: PMC12077226.
8. Adepoju P. Nigeria's plan to stop antibiotics being sold over the counter. Nature., Bamikole OJ, Olajide TH, Adedeji BA, Ademola SA, Fayehun AF, Bukoye NO et al. Drug use practices and self-treatment for suspected malaria in Ibadan, Nigeria. Am J Trop Med Hyg. 2023;108(6):1122–1126. doi: 10.4269/ajtmh.22-0489. PMID: 37068754; PMCID: PMC10540092.
9. Akande-Sholabi W, Ajamu AT. Antimicrobial stewardship: assessment of knowledge, awareness of antimicrobial resistance and appropriate antibiotic use among healthcare students in a Nigerian University. BMC Med Educ. 2021;21(1):488. 10.1186/s12909-021-02912-4. PMID: 34507579; PMCID: PMC8434738.
10. Olorunfemi O, Olorunfemi MB, Akerele TO, Oyelakin OA, Ayeni ET, Akerele AO, et al. Knowledge, attitude and practice of antimicrobial stewardship among healthcare professionals in a tertiary hospital in South-west Nigeria. Afr Health Sci. 2023;23(4):112–20. 10.4314/ahs.v23i4.14.
11. Fadare JO, Ogunleye O, Iliyasu G, Adeoti A, Schellack N, Engler D, Massele A, Godman B. Status of antimicrobial stewardship programmes in Nigerian tertiary healthcare facilities: findings and implications. J Glob Antimicrob Resist. 2019;17:132–6. 10.1016/j.jgar.2018.11.025.
12. Kiwango SJ, Mtoka SC, Manyangu LP, Mwapinga AC, Marandu FA, Senga R, et al. Comparison of knowledge, attitude, practice and predictors of self-medication with antibiotics among medical and non-medical students in Tanzania. Front Pharmacol. 2023;14:1301561. PMID: 38075114; PMCID: PMC10701192.
13. Gebregziabher NK, Netsereab TB, Franchesko BT, Ghebreamlak HH, Yihdego NM. Prevalence of self-medication practices with antibiotics and associated factors among students in five colleges in Eritrea: a cross-sectional study. Antimicrob Resist Infect Control. 2024;13(1):106. 10.1186/s13756-024-01466-6. PMID: 39300551; PMCID: PMC11414089.
14. Amuzie CI, Onyeonoro UU, Nwamoh UN, Ukegbu A, Kalu KU, Izuka MO. Prevalence and pattern of self-medication with antibiotics among residents of Abia State, Southeastern Nigeria: a call for action. Int J Community Med Public Health. 2024;11(11):4100–7. 10.18203/2394-6040.ijcmph20243278.
15. Popoola OO, Adepitan DS, Adeyemi AS, Oladeru OF, Yusuff SI. A national survey of the antibiotic use, self-medication practices, and knowledge of antibiotic resistance among graduates of tertiary institutions in Nigeria. Sci Afr. 2024;23:e01978. 10.1016/j.sciaf.2023.e01978.
16. Olanrewaju OA, Olanrewaju AY, Afolabi AB, Ayemibe OE. Evaluation of self-medication practices and associated factors: a cross-sectional study among residents of an urban community in Southwest Nigeria. IJID Reg. 2024;12:100392. 10.1016/j.ijregi.2024.100392.
17. Stephano EE, Lyimo OS, Godfrey VM, Shemdoe SG, James ME, Kingo RM, Self-medication practice and associated factors among health science students in Central Tanzania. East Afr, Health Res J, Qudrati BA, Sakhi R, Nikzad H, Qudrati SA. Prevalence of self-medication with antibiotics among nonmedical students at Kabul University, Afghanistan: a cross-sectional study. Medicine (Baltimore). 2025;104(34):e44124. doi:

10.1097/MD.0000000000044124. 22., Chizimu JY, Mudenda S, Yamba K, Lukwesa C, Chanda R, Nakazwe R, Antimicrobial stewardship situation analysis in selected hospitals in Zambia: findings and implications from a national survey. Front Public Health. 2024;12:1367703. doi: 10.3389/fpubh.2024.1367703. PMID: 39399248; PMCID: PMC11464303. 23. Agiri O, Osena G, Bahati F, Dill D, Kalanxhi E, Ashiru-Oredope D, Alimi YH et al. Knowledge, attitudes and practices survey on antimicrobial resistance and stewardship among pharmacy healthcare workers in 28 African countries. BMJ Glob Health. 2025;10(10):e019151. doi: 10.1136/bmjgh-2025-019151. PMID: 41130744; PMCID: PMC12551537.

18. Haque M, Rahman NAA, McKimm J, Kibria GM, Azim Majumder MA, Haque SZ, Self-medication of antibiotics: investigating practice among university students at the Malaysian National Defence University. Infect Drug Resist., Wahab A, Alam MM, Hasan S, Halder S, Ullah MO, Hossain A et al. Exploring the knowledge, practices & determinants of antibiotic self-medication among bangladeshi university students in the era of COVID-19: A cross-sectional study. Heliyon. 2023;9(9):e19923. 10.1016/j.heliyon.2023.e19923
19. Siachalinga L, Mufwambi W, Lee JH. Impact of antimicrobial stewardship on healthcare-associated infections and antibiotic prescriptions in African countries: systematic review and meta-analysis. J Infect Prev. 2026;27(1):3–16. 10.1177/17571774251377205.
20. Orok E, Ikpe F, Williams T, Akpan A, Effiong M, Bassey E, et al. Impact of educational intervention on knowledge of antimicrobial resistance and antibiotic use patterns among healthcare students: a pre- and post-intervention study. BMC Med Educ. 2025;25(1):283. 10.1186/s12909-025-06856-x.
21. Ogunnigbo O, Nabiryo M, Atteh M, Muringu E, Olaitan OJ, Rutter V, et al. Exploring the antimicrobial stewardship educational needs of healthcare students and the potential of an antimicrobial prescribing app as an educational tool in selected African countries. Antibiot (Basel). 2022;11(5):691. 10.3390/antibiotics11050691.
22. Nkaiwuatei J. Students Against Superbugs (SAS) Africa. ACS Infect Dis. 2022;8(7):1204–6. 10.1021/acsinfecdis.2c00243.
23. Tumwine C, Kiggundu R, Lwigale F, Mwanja H, Katumba H, Hope M, et al. Strengthening community antimicrobial stewardship in Africa: a systematic review of the roles, challenges, and opportunities of community health and animal health workers. Wellcome Open Res. 2025;10:346. 10.12688/wellcomeopenres.24387.1.
24. de Lima A, Buabeng K, Sakyi M, Chadwala H, Devereaux N, Mitambo C, et al. Bridging the capacity building gap for antimicrobial stewardship implementation: evidence from virtual communities of practice in Kenya, Ghana, and Malawi. Antibiot (Basel). 2025;14(8):724. 10.3390/antibiotics14080724.
25. Mohammed AS, Abrham D. Antimicrobial stewardship programs and antibiotic use in Africa: A systematic review and meta-analysis protocol. PLoS ONE. 2025;20(10):e0334758. 10.1371/journal.pone.0334758. PMID: 41105617; PMCID: PMC12533884.
26. Akpan AS, Udo MM, Bassey EB, Williams T, Orok E, Adedapo AA. Knowledge of antimicrobial stewardship and the Access, Watch and Reserve (AWaRe) classification of antibiotics among frontline healthcare professionals in Akwa Ibom State, Nigeria: a cross-sectional study. BMC Health Serv Res. 2024;24(1):1014. 10.1186/s12913-024-11428-8.
27. One Health Observatory. University students empower communities to tackle antimicrobial resistance. One Health Observatory News. 2024 Oct 24. Available from: https://onehealthobservatory.org/news/university-students-empower-communities-tackle-antimicrobial-resistance

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryFile1AntimicrobialUseAndStewardshipQuestionnaire.docx