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# Assessment of the knowledge, attitudes and perceived quality of education about antimicrobial use and resistance of medical students in Zambia, Southern Africa

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**Introduction:** Antimicrobial resistance (AMR) is a major global health threat, particularity in lower-middle-income countries (LMICs) where antibiotics are readily available, leading to antibiotic misuse. Educational interventions are lacking in Zambia. Our study assessed antimicrobial use and resistance knowledge, attitude and perceived quality of education relating to AMR in Zambian medical schools.

**Methods:** A cross-sectional anonymous survey of students at six accredited medical schools in Zambia using a self-administered questionnaire was administered, using Qualtrics. Chi-squared, Fisher exact test, Pearson correlation test and Student's *t*-tests were performed for descriptive analyses. Multivariable logistic regression was used to examine associations between knowledge and antibiotic use, beliefs and behaviours. Analysis was performed in SAS version 9.4.

**Results:** One hundred and eighty responses from six medical schools were included in the final analysis. Fifty-six percent of students rated their overall education on antibiotic use as useful or very useful. Ninety-one percent thought that antibiotics are overused, and 88% thought resistance was a problem in Zambia. Only 47% felt adequately trained on antibiotic prescribing, and 43% felt confident in choosing the correct antibiotic for specific infections. Only 2% felt prepared interpreting antibiograms, 3% were trained to de-escalate to narrow-spectrum antibiotics, 6% knew how to transition from IV antibiotics to oral antibiotics, 12% knew of dosing and duration, and 14% understood the spectrum of activity of antibiotics. Forty-seven percent of respondents think hand hygiene is unimportant.

**Conclusions:** Medical students in Zambia expressed a good level of knowledge, but low levels of training and confidence regarding antimicrobial prescribing practices and resistance. Our study highlights training gaps and possible areas of intervention in the medical school curriculum.

## Introduction

Antimicrobial resistance (AMR) is an established global health threat, and inappropriate prescribing practices by physicians have been implicated as a major contributing factor.[1,2] One cornerstone of global and national action plans to address AMR is to raise awareness;[3] however, focus on awareness occurs at different priority levels in different country settings. Antimicrobial stewardship is a key intervention to improve prescribing practices amongst medical professionals and within facilities.[4]

In Zambia, antibiotic stewardship programmes have recently been implemented to reduce antibiotic consumption, and a new antibiotic guideline has been developed to promote antibiotic stewardship within one university teaching hospital in Lusaka.[5] However, the existing AMR information in Zambia has important limitations. First, formal up-to-date baseline investigations have not yet been established within the country.[6] Second, existing programmes target pharmacists more than prescribing clinicians,[7,8] and have not yet reached outpatient and community

settings, where antibiotic prescribing occurs. Thirdly, infectious disease specialists teach and influence students in attaining knowledge on AMR;[9] however, they are a scarce resource.[10] Staff-to-population ratios nationally are as high as one GP per 14 500 people, and far fewer infectious disease specialists are available within the country.[6]

For low- and low-middle income countries (LLMICs), like Zambia, which are typically resource constrained, the availability and use of accurate and updated information becomes crucial for better allocation of resources and focused training of antimicrobial stewardship.[10] Antibiotics are often prescribed by junior doctors and GPs, regardless of knowledge and training, unlike in other disciplines where the use of drugs is restricted to superspecialists and is tightly regulated, as seen with chemotherapy in oncology.[11]

Zambia has a national action plan (NAP) with awareness and education as a strategic objective to be implemented by 2027.[6] To date, a desk review and survey to establish baseline data on curricula has not been established.

The Health Professions Council of Zambia (HPCZ), a statutory regulatory body established under the Health Professions Act No. 24, has identified six sites that have approved Bachelor of Medicine and Bachelor of Surgery programmes, namely: Copperbelt University School of Medicine (CBU); Mulungushi University; University of Zambia School of Medicine (UNZA); Cavendish University School of Medicine; Lusaka Apex Medical University (LAMU) and Texila American University.[12] There are more medical schools that offer the Bachelor of Medicine and Bachelor of Surgery; however, these programmes have not been verified by the HPCZ at the time of this study.

This project aimed to investigate the level of knowledge, attitudes and perceptions of appropriate antibiotic use and antibiotic resistance (ABR) among medical students in Zambia. The secondary objective was to explore associations between knowledge, attitudes and perceptions and the perceived quality of education relating to antibiotics and infection.

## Methods

### Study design, site and population

A cross-sectional web-based survey using the survey platform Qualtrics was conducted among first through to final year medical students from March 2021 to March 2022 to evaluate students' knowledge, attitudes and perceptions on antimicrobial use and resistance, and the sources and perceived quality of education about antimicrobials in six Zambian medical schools: Lusaka Apex Medical University, Cavendish University, University of Zambia, Mulungushi University, Texila University and Copperbelt University.

The structure and content of the survey were based on those used in previous similar studies[11,13–15] and were adapted for this setting by two infectious diseases specialists on the team. The questionnaire was pilot tested among 10 medical students for readability, length and relevance of specific items. The final questionnaire comprised four categories, including 35 questions on the following: (a) demographic characteristics (5 questions); (b) knowledge of antibiotics (9 questions); (c) attitudes and perceptions (12 questions); and (d) perceived quality of education (9 questions related to sources of gaining antibiotic knowledge, sources of information, eagerness to learn related knowledge, curriculum arrangement, and the appropriate use of antibiotics). The study was advertised using direct e-mails, class announcements and notices.

### Ethics

Informed consent was obtained prior to participation, which was voluntary and anonymously implemented in the Qualtrics survey. Ethics approval was obtained from the LAMU Research Ethics Committee in Lusaka, Zambia (Ref No.: 00187-21)—IRB number 00001131.

### Data analysis

Of the 194 survey responses, 14 were excluded due to missing information. The final analytical sample consisted of 180 participants. Cavendish University Zambia (CUZ) and Mulungushi University were collapsed into one category due lack of participants resulting in 6.3% of the total participants. The participating medical schools were de-identified as A to F to conduct blinded data analysis.

Overall knowledge was defined based on nine questions. Participants who scored <44.0% (4/9) for the knowledge questions were classified as deficient in knowledge while those who scored >88.9% were classified as having excellent knowledge. Participants scoring between 55.6% and 77.8% were classified as having good knowledge. Overall attitudes and perceptions were defined based on 12 questions. Participants who scored <41.7% for the attitudes and perceptions were classified as having deficient attitudes and perceptions, while those who scored between 50.0% to 75.0% were classified as having good attitudes and perceptions. Participants who scored >83.3% were classified as having excellent attitudes and perceptions. Knowledge on antibiotics was based on the correct answer on all antibiotics (amoxicillin, penicillin, tetracycline, metronidazole and sulfamethoxazole).

Chi-squared, Fisher exact test, Pearson correlation test and Student's *t*-tests were performed for descriptive analyses. Multivariable logistic regression was used to examine associations between knowledge and antibiotic use, beliefs and behaviours adjusted for gender and type of medical school. Analysis was performed in SAS version 9.4.

## Results

### Student population

One hundred and eighty responses from six medical schools were included in the analysis. The majority (58.0%) were female, 67.0% were between 20 and 35 years old, followed by 23.0% between 26 and 30 years old, 5.6% less than 20 years old, and 4.0% between 31 and 40 years old. Medical schools A and B, and medical school C represented only 6.2%, respectively, followed by medical school E (9.1%), medical school F (10.8%) and with the majority at medical school D (67.6%). Eighty percent of the students were from private medical schools. About 74.1% were first-year medical students (Table 1). Fifty-three percent had a previous degree. Table 1 summarizes the population characteristics of medical students in Zambia.

### Knowledge and attitudes

In general, students had good to excellent overall knowledge, attitudes and perceptions on AMR, with no differences when comparing public and private medical schools. Overall, knowledge in public medical schools compared with private was as follows: deficient (6.1% versus 3.2%, $P=0.3446$), good (45.5% versus 44.9%, $P=0.8195$) and excellent (48.5% versus 52.0%, $P=0.8810$). Similarly, overall attitudes and perceptions among public medical schools compared with private schools were as follows: deficient (0.0% versus 2.5%, $P=1.0000$), good (69.7% versus 68.3%, $P=0.4497$) and excellent (30.3% versus 29.2%, $P=0.6670$).

**Table 1.** Population characteristics of medical students in Zambia, 2021

| | *n* (%) (*N* = 180) |
|---|---|
| Age, years | |
| Less than 20 | 10 (5.6) |
| 20–25 | 118 (67.1) |
| 26–30 | 41 (23.3) |
| 31–40 | 7 (4.0) |
| Gender | |
| Female | 102 (58.0) |
| Male | 67 (38.0) |
| Prefer not to say | 7 (4.0) |
| Medical school sites | |
| Universities A and B | 11 (6.2) |
| University C | 11 (6.2) |
| University D | 119 (67.6) |
| University E | 16 (9.1) |
| University F | 19 (10.8) |
| Medical school type | |
| Public[a] | 36 (20.0) |
| Private[b] | 144 (80.0) |
| Previous degrees | |
| BSc (Other) | 12 (7.0) |
| BSc Human Biology | 80 (46.2) |
| Not Applicable | 81 (46.8) |
| Stage of medical school | |
| Pre-clinical year[c] | 88 (53.0) |
| Clinical year[d] | 78 (47.0) |
| Year of study | |
| 3rd | 63 (38.0) |
| 4th | 25 (15.5) |
| 5th | 24 (14.5) |
| 6th | 34 (20.5) |
| 7th | 20 (12.0) |

[a]University of Zambia, Copperbelt University and Mulungushi University; [b]Cavendish University Zambia, Lusaka Apex Medical University, Texila University; [c]corresponded to the third and fourth year at the universities; [d]corresponded to the fifth to seventh year at the medical programme, with the exception of Copperbelt University, which ends at the sixth year.

Knowledge on antibiotics among public medical schools was 27.8% compared with 31.3% among private medical schools, $P = 0.6858$ (Table 2).

When comparing among medical schools, we observed that four medical schools had approximately half of the students with excellent overall knowledge on ABR. One medical school had 20.0% of students with deficient knowledge on ABR (Figure 1a). Attitudes and perceptions on ABR ranged from 18.0% to 30.0% being excellent for five medical schools, but not for medical school C at 50.0% (Figure 1b).

The most frequently reported training competencies needed for newly qualified doctors to prescribe antibiotics were more exposure to infectious disease specialists (57.0%), followed by a local handbook/guideline on treating common infections (54.0%) and more formal lectures (43.0%).

Students in the clinical year of medical school were six times [adjusted OR (aOR) 6.2, 95% CI 1.5–25.1] more likely to have excellent overall knowledge on ABR compared with pre-clinical year students. They were almost four times [3.7 (1.1–12.5)] more likely to know specific antibiotics when compared with students in the pre-clinical year of medical school,. Compared with pre-clinical year students, students in the clinical year were almost nine times [8.8 (2.1–38.0)] more likely to make an accurate diagnosis of infection, about 8 times [8.4 (2.3–30.6)] more likely to understand the basic mechanisms of ABR, about 7 times [6.7 (1.6–27.0)] more likely to know when to start antibiotics, about 6 times [6.5 (1.8 –23.5)] more likely to have the knowledge of dosing and duration of antibiotic therapy for specific infection, about 5 times [4.8 (1.4–16.5)] more likely to choose the correct antibiotic for a specific infection, and about 4 times [3.8 (1.1–13.0)] more likely to understand the spectrum of activity of commonly used antibiotics (Tables S1 and S2, available as Supplementary data at *JAC-AMR* Online).

### Education

Fifty-six percent of students rated their overall education on antibiotic use as useful or very useful. Most students reported that they would like more education on ABR (98.0%), and 96.7% would appreciate more education on appropriate use of antibiotics. Across all universities, respondents attended lectures or tutorials specifically addressing making a diagnosis (19.9%), indications for starting antibiotics (16.5%), dosing and duration of antibiotic therapy (14.3%), indications of IV antibiotics (9.8%), rational use of antibiotics (9.6%), infection prevention and control (15.4%) and antibiotic stewardship (2.4%). The usefulness of educational sources with regard to ABR, and antibiotic prescribing, and pharmacology are summarized in Tables 3 and 4. Students reported patient-based learning (PBL) and registrar rounds as being the least useful sources of information. The most common resources for learning about prescribing and ABR were formal education (32.0%) and bedside tutorials (18.0%).

### Preparedness

Figure 2 summarizes students' assessment of preparedness in various aspects of antibiotic prescribing. Students felt least prepared in topics that addressed interpretation of antibiograms (2.3%), de-escalating to narrow-spectrum antibiotics (3.4%), transition from IV antibiotics to oral antibiotics (6.2%), knowledge of dosing and duration (11.6%) and understanding the spectrum of activity of commonly used antibiotics (14.1%). The most popular measure to improve preparedness of new doctors was more exposure to infectious disease specialists (19.9%) and a local guideline on treating common infections (18.9%), followed by more formal lectures (14.9%), more time in microbiology (13.2%) and bedside tutorials (13.2%). The least popular measures were smartphone applications (10.3%) followed by computer-based tutorials (7.6%). Mobile applications assessed were applications like Medscape, Medinaz, VisualDx, Peads OSCE Q&A.

### Perceptions

Respondents' perceptions about the causes and impact of AMR are summarized in Tables 3 and 4. Ninety-one percent thought that antimicrobials are overused, and resistance (88.7%) is a

**Table 2.** Secondary outcomes of knowledge, attitudes and perceptions on ABR of medical students at community-based medicine, by public and private universities in Zambia, 2021

| | Medical school type | | Total of students ($n=180$) | *P* value |
|---|---|---|---|---|
| | Public[a] | Private[b] | | |
| Overall knowledge, *n* (%)[c] | | | | |
| Deficient | 2 (6.1) | 4 (3.2) | 6 (3.75) | 0.3446 |
| Good | 15 (45.5) | 57 (44.9) | 72 (45.0) | 0.8195 |
| Excellent | 16 (48.5) | 66 (52.0) | 82 (51.3) | 0.8810 |
| Overall attitudes and perceptions, *n* (%)[d] | | | | |
| Deficient | 0 (0.0) | 3 (2.5) | 3 (2.0) | 1.0000 |
| Good | 23 (69.7) | 82 (68.3) | 105 (68.6) | 0.4497 |
| Excellent | 10 (30.3) | 35 (29.2) | 45 (29.4) | 0.6670 |
| Knowledge on antibiotics[e] | 10 (27.8) | 45 (31.3) | 55 (30.6) | 0.6858 |
| Formal lectures on antibiotic and overall knowledge, *n* (%)[c] | | | | |
| Deficient | 2 (6.9) | 2 (2.2) | 4 (3.3) | 0.2391 |
| Good | 13 (44.8) | 41 (44.1) | 54 (44.3) | 1.0000 |
| Excellent | 14 (48.3) | 50 (53.8) | 64 (52.4) | 0.6054 |
| Formal lectures on antibiotic prescribing and resistance and overall knowledge, *n* (%)[c] | | | | |
| Deficient | 0 (0.0) | 2 (2.2) | 2 (1.6) | 1.0000 |
| Good | 21 (72.4) | 62 (66.7) | 83 (68.0) | 0.5623 |
| Excellent | 8 (27.6) | 29 (31.2) | 37 (30.3) | 0.7130 |
| Formal lectures on antibiotic and overall attitudes and perceptions, *n* (%)[d] | | | | |
| Deficient | 2 (7.1) | 2 (2.4) | 4 (3.6) | 0.2598 |
| Good | 12 (42.9) | 40 (47.6) | 52 (46.4) | 0.6617 |
| Excellent | 14 (50.0) | 42 (50.0) | 56 (50.0) | 1.0000 |
| Formal lectures on antibiotic prescribing and resistance and overall attitudes and perceptions, *n* (%)[d] | | | | |
| Deficient | 0 (0.0) | 2 (2.4) | 2 (1.8) | 1.0000 |
| Good | 20 (71.4) | 54 (64.3) | 74 (66.1) | 0.4894 |
| Excellent | 8 (28.6) | 28 (33.3) | 36 (32.1) | 0.6403 |

[a]University of Zambia, Copperbelt University and Mulungushi University; [b]Cavendish University Zambia, Lusaka Apex Medical University, Texila University; [c]overall knowledge was defined based on nine questions, and categorized according to the percentage of correct answers as following: deficient knowledge (0%–44.4%), good knowledge (44.5%–77.8%) and excellent knowledge (above 77.8%); [d]overall attitudes and perceptions was defined based on 12 questions, and categorized according to the percentage of correct answers as follows: deficient attitudes and perceptions (0%–41.7%), good attitudes and perceptions (41.8.0%–75.0%) and excellent attitudes and perceptions (above 75.0%); [e]based on correct answer on all antibiotics: amoxicillin, penicillin, tetracycline, metronidazole and sulfamethoxazole.

problem in Zambia. Forty-seven percent of respondents disagreed that the 'lack of hand hygiene by healthcare workers causes the spread of antibiotic resistance.' Almost all respondents agreed that good knowledge of antibiotics is important to medical doctors (98.0%), and inappropriate use of antibiotics contributes to resistance (96.7%). Eighty-nine percent believed that inappropriate use of antibiotics directly harms patients.

## Discussion

This is the first formal assessment of Zambian medical students' perceptions about their preparedness to prescribe antibiotics. There were three major findings, which are consistent with observations from high-income countries:[15] (i) inadequate knowledge of basic antibiotic prescribing practice; (ii) a desire for more education in this area; and (iii) a perceived lack of preparedness and confidence to prescribe antibiotics.

In Zambia, antibiotics can be prescribed by junior medical doctors and non-specialists. There are limited opportunities for postgraduate training focused on antibiotic stewardship. Inadequate preparation at medical school may translate into widespread antibiotic misuse and further perpetuate ABR. Our findings are worrying and serve as a call for intervention.

A traditional measure to improve knowledge is quantifying the effectiveness of education.[11] A key objective of antimicrobial stewardship education is to shift the attitudes, perceptions and improve prescribing behaviour by healthcare workers.[16,17]

Although almost all students recognized that AMR and the overuse of antibiotics is a concern in Zambia, the exposure to learning opportunities to curb AMR is almost non-existent. Many hospitals have not implemented an antibiotic guideline, with more than half of the respondents having never consulted antibiotic guidelines when considering antibiotics for a patient. This disconnect between personal responsibility and perception

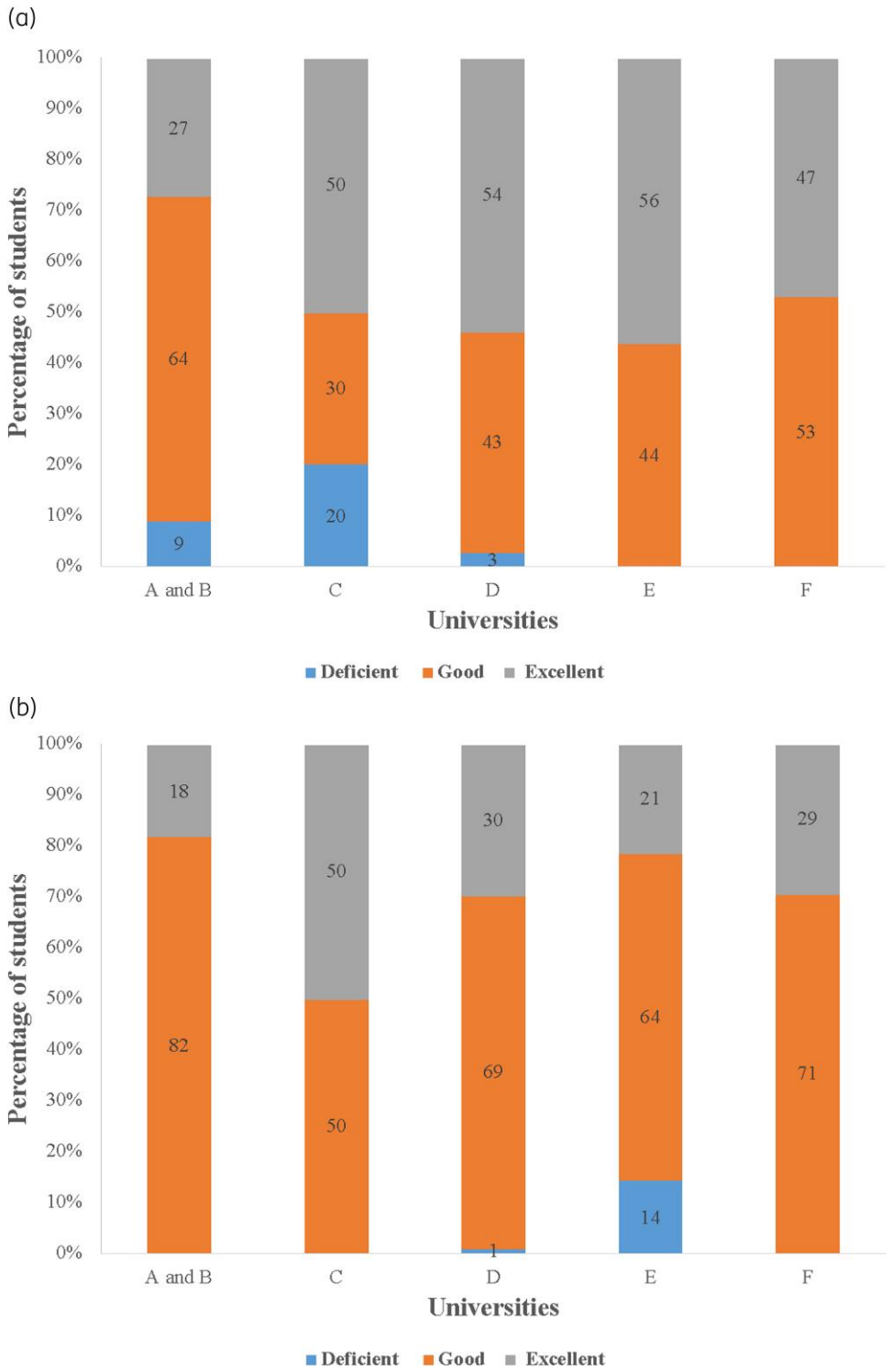


**Figure 1.** Knowledge (a) and attitudes and perceptions (b) on ABR by universities in Zambia, 2021.

of practice has been recognized amongst medical students in other settings.[13,18]

A troubling finding from our survey was the perception that hand hygiene was not important, whereas it is a significant factor contributing to the spread of AMR.[19] Similar responses were found in the European medical student study, where students felt that hand hygiene was unimportant.[15]

While most students felt prepared to diagnose infections accurately, few students reported feeling well prepared about deciding when to initiate antibiotic use, and the use of

**Table 3.** Knowledge and attitudes, breakdown of questions

| Variable | Questions | Yes ($n=160$) | No ($n=160$) |
|---|---|---|---|
| Knowledge questions | K1—Are there any bacteria in human bodies which can be helpful for us? (Correct answer = Yes) | 158 | 2 |
| | K2—Can antibiotics be used to cure infections caused by bacteria? (Correct answer = Yes) | 159 | 1 |
| | K3—Can antibiotics be used to cure infections caused by viruses? (Correct answer = No) | 16 | 143 |
| | K4—Should one stop taking a course of antibiotics early, without consulting the prescriber, when one feels well? (Correct answer = No) | 7 | 152 |
| | K5—Have you heard of the term 'antimicrobial resistance'? (Correct answer = Yes) | 153 | 7 |
| | K6—Do you think frequent use of antibiotics can decrease occurrence of infection? (Correct answer = No) | 39 | 120 |
| | K7—Do you think the use of antibiotics will speed up the recovery of viral coughs and colds? (Correct answer = No) | 32 | 127 |
| | K8—Is the efficacy better if the antibiotics are more recent and the price is higher? (Correct answer = No) | 47 | 110 |
| Attitude questions | A1—Is antibiotic resistance a problem in Zambia? (Correct answer = Yes) | 134 | 17 |
| | A2—Are antibiotics overused in Zambia? (Correct answer = Yes) | 139 | 13 |
| | A3—Does the overuse of antibiotics result in antibiotic resistance? (Correct answer = Yes) | 147 | 5 |
| | A4—Are new antibiotics available to deal with the problem of resistance? (Correct answer = No) | 65 | 86 |
| | A5—Does inappropriate use of antibiotics cause antibiotic resistance? (Correct answer = Yes) | 147 | 5 |
| | A6—Will better use of antibiotics reduce levels of antibiotic resistance? (Correct answer = Yes) | 148 | 3 |
| | A7—Can the use of broad-spectrum antibiotics increase antibiotic resistance, when equally effective narrower-spectrum antibiotics are available? (Correct answer = Yes) | 115 | 34 |
| | A8—Does the lack of hand hygiene by healthcare workers cause the spread of antibiotic resistance? (Correct answer = Yes) | 77 | 71 |
| | A9—Is inappropriate use of antibiotics directly harmful to patients? (Correct answer = Yes) | 136 | 16 |
| | A10—Will a good knowledge of antibiotics be important to your work as a medical doctor? (Correct answer = Yes) | 152 | 0 |
| | A11—Would you like more education on antibiotic resistance? (Correct answer = Yes) | 149 | 3 |
| | A12—Would you like more education on the appropriate use of antibiotics? (Correct answer = Yes) | 147 | 5 |

narrow-spectrum versus broad-spectrum antibiotics. Some studies term this as overconfidence and it has been identified in their settings,[11,20] which may lead to further overprescribing and malprescribing behaviours. These findings are important indicators that medical education needs to be supplemented with approaches that can better influence prescribing behaviours. The appeal expressed by most students for more education on antibiotic prescribing and AMR in general represents an empowering factor and an educational opportunity across the country.

Our study highlighted the usefulness of various educational sources, and further provides insights into which interventions may be more effective. Across all universities, formal education (lectures) was the main source of learning. The content of the lectures was further assessed, and it was noted that most students were taught about diagnosis of an infection followed by indications for starting antibiotics. The dosage and duration of antibiotics and principles of infection prevention and control were noted in half the universities, whereas lectures addressing indications for IV antibiotics, rational use of antibiotics, and antibiotic stewardship were not tackled in the majority of the responses. Most respondents felt that a local handbook or guideline on treating common infections, and more exposure to infectious disease specialists would better prepare students on prescribing practices and behaviours.

By making AMR a core component in professional medical education, the proper understanding and awareness among medical doctors can improve awareness and understanding of AMR;[17] however, this has a limited impact on improving antibiotic use on its own.[11,21] Bedside tutorials, formal lectures and more time in microbiology were the least popular methods suggested to improve preparedness for antibiotic prescription. This suggests that more innovative, unique and engaging educational approaches are needed to complement traditional lectures in the tackle against AMR. Some of these approaches, which include gamification and clinical case discussions are considered more effective for improving awareness and promoting expert-driven behavioural change.[16] Some medical schools in high-income countries have acknowledged the gaps and included PBL approaches in their curriculums. PBL assists in long-term retention and skill development,[22] thus improving behavioural practices of clinicians in the long run. Our study showcased these PBL sessions, computer-based learning and phone applications as the most unpopular sources to improve skills and preparedness, indicating potential room for change of mindset and adaptation to learning styles across Zambia. These mobile applications mentioned are more literature based and require reading; they are essentially eBooks that students felt were not captivating. A potential area for improvement and innovation would be

**Table 4.** Usefulness of educational sources

| Topics covered | University | Types of education sources: Formal education (lectures) | Bedside tutorials | Consultant tutorials | Registrar rounds | PBL | Other |
|---|---|---|---|---|---|---|---|
| Antimicrobial prescribing and resistance, % (rounded) | LAMU | 60 | 63 | 63 | 63 | 68 | 70 |
| | UNZA | 14 | 19 | 23 | 22 | 14 | 13 |
| | CBU | 7 | 10 | 9 | 11 | 11 | 7 |
| | CUZ | 4 | 2 | 2 | 2 | 0 | 0 |
| | TAN | 11 | 5 | 4 | 2 | 7 | 10 |
| | Mulungushi | 4 | 1 | 0 | 0 | 0 | 0 |
| | Total | 32 | 18 | 16 | 13 | 13 | 9 |
| Antibiotics, % (rounded) | LAMU | 65 | 64 | 72 | 67 | 70 | 64 |
| | UNZA | 12 | 18 | 16 | 13 | 8 | 23 |
| | CBU | 6 | 7 | 3 | 6 | 10 | 0 |
| | CUZ | 4 | 4 | 5 | 4 | 3 | 0 |
| | TAN | 9 | 5 | 3 | 4 | 7 | 14 |
| | Mulungushi | 4 | 2 | 0 | 0 | 2 | 0 |
| | Total | 30 | 15 | 16 | 15 | 17 | 6 |
| Antibiotic classes and spectrum of activity, % (rounded) | LAMU | 63 | 62 | 63 | 60 | 63 | 70 |
| | UNZA | 14 | 23 | 24 | 24 | 19 | 15 |
| | CBU | 7 | 8 | 9 | 11 | 11 | 5 |
| | CUZ | 4 | 2 | 2 | 2 | 2 | 0 |
| | TAN | 9 | 3 | 2 | 2 | 6 | 10 |
| | Mulungushi | 3 | 2 | 0 | 0 | 0 | 0 |
| | Total | 33 | 16 | 15 | 12 | 1 | 11 |

gamification. Gamification is the use of games for educational purposes; students have an opportunity to play a game while learning crucial information.[23,24]

In the hospital, consultant and registrar rounds are often used to educate learners during their clinical rotations. The respondents found this source of learning as the least popular source to gain information about drug resistance, and prescribing behaviours. This is an interesting finding as the consultants and registrars will revise the prescription (drug and dosage) specifically for the patient by consulting the antibiograms as well as the microscopy, culture and sensitivity results thus providing a unique opportunity to discuss concepts like AMR, approach to diagnosis, infection prevention and a revision of classes of drugs suited for different infections. Overall, there were significant similarities in responses across all institutions. Most of the medical institutions send students into the same hospitals for their clinical training, thereby verifying the ground-level interactions between consultants, registrars, interns and undergraduates. This further consolidates the opportunities for learning relating to the access of antibiograms, infectious disease specialists and microbiologists are independent of the formal learning opportunities at the various universities. There were, however, significant differences in the overall knowledge scores between the six medical schools in Zambia, suggesting that the content of the formal lectures has an impact on antibiotic prescribing and stewardship. There is a need to develop a standardized curriculum addressing AMR, antimicrobial stewardship and a revision of pharmacology at an undergraduate level. Notably, the different structures of the universities make it difficult to ascertain when students should be taught about AMR. Some universities incorporate AMR in their microbiology courses, while others incorporate it in their pharmacology courses. To date, there is not a known course that highlights the importance of AMR as a subject matter. This highlights the need for an intervention in the medical school curriculum to include AMR as a core component. This will benefit all medical students in preparing them for future prescribing, addressing the need for substantial behavioural changes at the grassroots level. Re-evaluating PBL, integrating registrar and consultant rounds across all institutions, and introducing innovative ways to teach medical students about the threat of AMR should be considered to ensure a more careful approach to antibiotic prescribing. To prevent the increase of AMR, an adequate educational approach is needed to anyone involved in prescribing.[25]

Our findings may not be generalized to all schools in Zambia as there are differences in teaching schedules, and it is unknown in which year medical students are taught about drug resistance in a formal setting. Our paper surveyed medical students who were in the first year of their pre-clinical studies, thus representing 38% of the responses, which could lead to skewed results as first-year students are likely to know less than those in final year. Despite these limitations, our findings provide valuable baseline data and highlight the need for a tailored curriculum for AMR and antimicrobial stewardship content. Strengths of this study include the use of a tailored online survey specific for the context of Zambia, and data collection took place at the end of the academic year, which meant students may have presented better knowledge compared with any other time of the year because of the effect of exam revision.

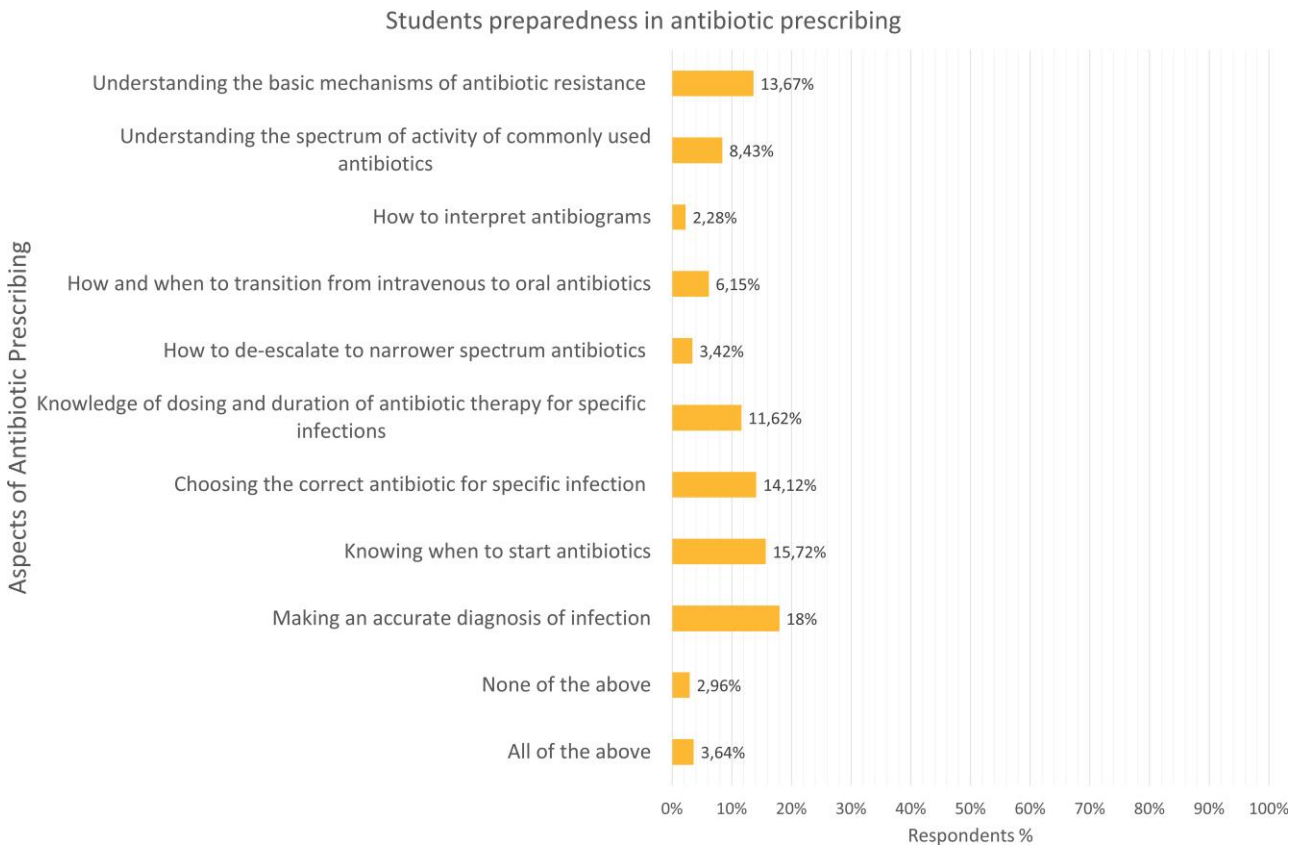


**Figure 2.** Students' preparedness in various aspects of antibiotic prescribing.

## Conclusions

This survey has exposed training gaps and raises concerns about the readiness of our future prescribers. Medical students in Zambia expressed a good level of knowledge, but a low level of training and confidence regarding antimicrobial prescribing practices and resistance. As well as training gaps, our study highlights possible areas of intervention in the medical school curriculum.

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## Transparency declarations

All authors have declared no conflict of interest.

## Supplementary data

Table S1 and S2 are available as Supplementary data at *JAC-AMR* Online.

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