

**Original Article****Open Access****Knowledge of antibiotic resistance and habits of antibiotic use among medical students of University of Nigeria Enugu: a descriptive cross-sectional survey**

¹Nwafia, I., ²Nwafia, S., ²Ibeh, P, *³Ajunwa, K., ²Obaje, O., ²Ehimiyen, R., ²Nwachukwu, L., ²Promise, G., ²Eze, S., ²Igono, F., ²Okoli, N., and ²Nwadike, S.

¹Department of Medical Microbiology, Faculty of Basic Clinical Sciences, College of Medicine, University of Nigeria, Ituku-Ozalla Campus, Enugu State, Nigeria

²Faculty of Clinical Sciences, College of Medicine, University of Nigeria, Ituku-Ozalla Campus, Enugu State, Nigeria

³Microbiology Research Laboratory, Alex Ekwueme Federal Teaching Hospital, Abakaliki, Ebonyi State, Nigeria

*Correspondence to: ajunwakelechi@gmail.com; +2348062402014

Abstract:

Background: The adverse effects of antimicrobial resistance (AMR) are manifesting worldwide. A major contributing factor to AMR is the inappropriate use of antimicrobials in humans and animals. It is imperative to raise awareness among medical students of the current public health challenges of AMR and make them antibiotic guardians because they are the future medical doctors. This survey was designed to assess the knowledge of AMR and habits of antimicrobial use (AMU) among medical students as a means to guide them in their future practice.

Methodology: This descriptive cross-sectional survey was conducted among medical students of the College of Medicine, University of Nigeria (UNN), Enugu State, Nigeria, from July to September 2021. The sample size of 602 was calculated using an online Raosoft sample size calculator. Pretested structured questionnaires, designed to collect information on students' knowledge of antimicrobials and factors responsible for emergence of AMR as well as the students' habits of antimicrobial use, were self-administered to consenting students. The data were analyzed using descriptive and inferential statistics.

Results: Of the 602 questionnaires administered to the students, 550 were filled out, giving a response rate of 91.4%. Out of the 550 respondents, 60.4% were females, majority (51.1%) of the respondents were between the ages of 21 and 25 years. Regarding knowledge, 97.2%, 62.5%, and 54.2% have heard of the terms 'antibiotic resistance', 'multi-drug drug resistance' and 'antimicrobial stewardship' respectively. About 97.3% knew that AMR was a global problem, however only 64.7% felt that it was a problem for medical students. Surprisingly, 20.4% indicated that viruses were sensitive to antibiotics. Regarding the students' habit of antimicrobial use, only 22.2% always consult a doctor before starting an antibiotic, 13.1% go for laboratory tests, and 90.5% always take antibiotics anytime they have a fever. Above half of the participants (56.5%) do not complete the dosage of the antibiotics while 63.5% keep leftover antibiotics for future use. In assessing the factors responsible for AMR emergence, 88.8% responded not adhering to a doctor's prescription and 92.0% responded poor quality of drugs, while only 42.8% responded that overuse of antibiotics in livestock is a factor.

Conclusion: Our study gave an insight into the knowledge gap and the need to increase awareness and education on AMR and AMS among the medical students, especially in the early phase of their academic and professional training.

Keywords: Antimicrobial use; Antimicrobial resistance; Knowledge; Habits; Medical students

Received Dec 17, 2023; Revised Jun 3, 2024; Accepted Jun 5, 2024

Copyright 2024 AJCEM Open Access. This article is licensed and distributed under the terms of the Creative Commons Attribution 4.0 International License http://creativecommons.org/licenses/by/4.0/, which permits unrestricted use, distribution and reproduction in any medium, provided credit is given to the original author(s) and the source. Editor-in-Chief: Prof. S. S. Taiwo

Connaissance de la résistance aux antibiotiques et des habitudes d'utilisation des antibiotiques parmi les étudiants en médecine de l'Université du Nigéria à Enugu: une enquête transversale descriptive

¹Nwafia, I., ²Nwafia, S., ²Ibeh, P, *³Ajunwa, K., ²Obaje, O., ²Ehimiyen, R., ²Nwachukwu, L., ²Promise, G., ²Eze, S., ²Igono, F., ²Okoli, N., et ²Nwadike, S.

¹Département de Microbiologie Médicale, Faculté des Sciences Cliniques Fondamentales, Collège de Médecine, Université du Nigéria, Campus Ituku-Ozalla, État d'Enugu, Nigéria

²Faculté des Sciences Cliniques, Collège de Médecine, Université du Nigéria, Campus Ituku-Ozalla, État d'Enugu, Nigéria

³Laboratoire de Recherche en Microbiologie, Hôpital Universitaire Fédéral Alex Ekwueme, Abakaliki, État d'Eboyi, Nigeria

*Correspondance à : ajunwakelechi@gmail.com; +2348062402014

Résumé:

Contexte: Les effets néfastes de la résistance aux antimicrobiens (RAM) se manifestent dans le monde entier. L'un des principaux facteurs contribuant à la RAM est l'utilisation inappropriée d'antimicrobiens chez les humains et les animaux. Il est impératif de sensibiliser les étudiants en médecine aux enjeux de santé publique actuels liés à la RAM et d'en faire les gardiens des antibiotiques car ils sont les futurs médecins. Cette enquête a été conçue pour évaluer les connaissances sur la RAM et les habitudes d'utilisation des antimicrobiens (UMA) parmi les étudiants en médecine afin de les guider dans leur pratique future.

Méthodologie: Cette enquête transversale descriptive a été menée auprès d'étudiants en médecine de la Faculté de médecine de l'Université du Nigéria (UNN), dans l'État d'Enugu, au Nigéria, de juillet à septembre 2021. La taille de l'échantillon de 602 a été calculée à l'aide d'un échantillon en ligne de Raosoft calculatrice. Des questionnaires structurés prétestés, conçus pour recueillir des informations sur les connaissances des étudiants en matière d'antimicrobiens et de facteurs responsables de l'émergence de la RAM, ainsi que sur leurs habitudes d'utilisation des antimicrobiens, ont été auto-administrés aux étudiants consentants. Les données ont été analysées à l'aide de statistiques descriptives et inférentielles.

Résultats: Sur les 602 questionnaires administrés aux étudiants, 550 ont été remplis, soit un taux de réponse de 91,4%. Sur les 550 répondants, 60,4% étaient des femmes, la majorité (51,1%) des répondants étaient âgés de 21 à 25 ans. Concernant les connaissances, 97,2%, 62,5% et 54,2% ont respectivement entendu parler des termes «résistance aux antibiotiques», «résistance multidroque» et «gestion des antimicrobiens». Environ 97,3% savaient que la RAM était un problème mondial, mais seulement 64,7% estimaient qu'il s'agissait d'un problème pour les étudiants en médecine. Étonnamment, 20,4% ont indiqué que les virus étaient sensibles aux antibiotiques. Concernant l'habitude des étudiants en matière d'utilisation des antimicrobiens, seuls 22,2% consultent toujours un médecin avant de commencer un antibiotique, 13,1% passent des analyses de laboratoire et 90,5% prennent toujours des antibiotiques chaque fois qu'ils ont de la fièvre. Plus de la moitié des participants (56,5%) ne terminent pas le dosage des antibiotiques tandis que 63,5% conservent les antibiotiques restants pour une utilisation future. En évaluant les facteurs responsables de l'émergence de la RAM, 88,8% ont répondu le non-respect des prescriptions médicales et 92,0% ont répondu que les médicaments étaient de mauvaise qualité, tandis que seulement 42,8% ont répondu que la surutilisation d'antibiotiques chez le bétail était un facteur.

Conclusion: Notre étude a donné un aperçu du manque de connaissances et de la nécessité d'accroître la sensibilisation et l'éducation sur la RAM et l'AMS parmi les étudiants en médecine, en particulier dans la phase précoce de leur formation académique et professionnelle.

Mots clés: Utilisation d'antimicrobiens; Résistance aux antimicrobiens; Connaissances; Habitudes; Étudiants en médecine

Introduction:

It has been said that the discovery of antibiotics represents the single biggest historical gain in healthcare. After antibiotics were developed and widely used, the mortality linked to several previously lethal illnesses significantly decreased. Antimicrobial drugs are the bedrock of modern medicine and improve average life expectancy and quality of life generally. However, the emergence and spread of antimicrobial resistance (AMR) are challenging the ability to treat and contain infectious diseases (1). The irresponsible use of antimicrobial agents is the main factor speeding up the process of emergence of AMR (2), although this can happen naturally over time through genetic changes.

It has been reported that about 60% of antimicrobial drugs in both therapy and prophylaxis are considered inappropriate (3). The adverse effects of AMR are manifesting worldwide and the World Health Organization has rated AMR among the top ten public health threats (4), with the burden being higher

in middle-and-low-income countries, including Nigeria. Many cases of AMR have been reported in Nigeria and beyond. As AMR raises healthcare costs and prolongs disability (1), it continues to pose a danger to the effective prevention and treatment of a wide range of illnesses.

Medical doctors have a major role to play in reversing the scourge of AMR because they prescribe antibiotics during routine clinical practice, promote health education, and encourage patients to strictly adhere to antimicrobial therapy and avoid self-medication (5). Moingtui and colleagues (6) observed that intake of antimicrobials without prescription and improper physician prescriptions, among others, are some of the variables that contribute to the rise in AMR. Thus, any change in prescribing behaviour promoting responsible antibiotic use through interventions in education may help to tackle AMR.

Medical students are future doctors therefore, it is imperative to make them aware of current public health issues and integrate them into appropriate prescribing prac-

tices. Previous researchers have recommended that AMR interventions targeting responsible antimicrobial use should be introduced early in the medical career and continued until the postgraduate level (7,8). According to a Nigerian study, medical students only had mediocre understanding of antibiotic resistance, which emphasizes the need for improved education and awareness (9). Mudenda et al., (10), observed that undergraduate medical students from Zambia need to improve their practices even though they showed acceptable knowledge and attitudes regarding antibiotic use and resistance. The WHO has also highlighted the importance of adequate training for medical students in responsible antimicrobial prescribing (11). The Global Action Plan (GAP) on AMR stated education, knowledge and training as part of their objectives, emphasizing their importance in the fight against AMR (12). Thus, medical students play a major role in combating the spread of AMR because the knowledge they acquired during their training will help promote responsible antimicrobial prescribing and antimicrobial use.

Realizing the importance of medical students in combating AMR, we designed this study with the aim of assessing the knowledge of AMR and habits of antibiotic use among medical students of University of Nigeria, Enugu, Nigeria. This will help provide advice on the target area for intervention in order to combat the rising incidence of AMR.

Materials and method:

Study setting:

The study was conducted among medical students at the College of Medicine, University of Nigeria (UNN). UNN is a federal university and the first indigenous university in Nigeria. The university has three campuses for medical students; the first campus is located in Nsukka for the first-year pre-clinical students, the second campus is in Enugu for the second- and third-year pre-clinical students, and the third campus is in Ituku-Ozalla for the fourth-, fifth- and sixth-year clinical students. The college has over 1000 students across the six study levels.

Ethical consideration:

The study protocol was approved by the Research and Health Ethics Committee of the University of Nigeria Teaching Hospital

(UNTH) Enugu. Informed consent of each study participant was obtained.

Study design, participants & sampling:

This was a descriptive cross-sectional survey conducted from July to September 2021 among medical students at different levels of study using a self-administered questionnaire. The sample size for the study was calculated using an online Raosoft calculator with a 5% error margin and 95% confidence interval, which gave a sample size of 602. The study participants were recruited by the simple random sampling technique.

Data collection:

The questionnaire was created after intense literature review and contained four sections; the first section collected information on demographic characteristics of the participants, the second section assessed the knowledge of antimicrobials and AMR, the third assessed the habits of antimicrobial use and the fourth section assessed knowledge of the factors responsible for emergence of AMR. The questionnaire was first pilot-tested among 20 medical students who were randomly selected from different years of study, before being self-administered to the study participants.

Data analysis:

Data were entered in Microsoft Excel, 2016 version and analysed using the Statistical Package for the Social Sciences (SPSS). Descriptive analysis for categorical analysis was done using frequencies and proportions.

Results:

Sociodemographic characteristics of the study participants:

A total of 602 questionnaires were administered to the study participants but 550 questionnaires were completely filled, given a response rate of 91.36%. Out of the 550 study participants, 56.0% were females, with majority (40.2%) being within the ages of 21-25 years, followed by 26-30 years (32.9%) and the least (1.5%) being 31-35 years. With regards to the years (level) of study, 22.0% were in 400 level (4th year), 21.6% in 200 level (2nd year), 18.9% in 500 level and 18.4% in 300 level. Majority (91.3%) of the participants were single (Table 1).

Table 1: Socio-demographic characteristics of the study participants

Characteristics	Frequency	Percentage
Age group (years)		
15-20	140	25.5
21-25	221	40.2
26-30	181	32.9
31-35	8	1.5
Gender		
Male	242	44.0
Female	308	56.0
Marital status		
Single	502	91.3
Married	48	8.7
Year (level) of study		
100	50	9.1
200	119	21.6
300	101	18.4
400	121	22.0
500	104	18.9
600	55	10.0
Ethnicity		
Igbo	527	95.8
Hausa	8	1.5
Yoruba	11	2.0
Others	4	1.0

Table 2: Knowledge of medical students on antibiotics use and resistance

Question	Frequency of response	Percentage
Have you heard about antibiotics resistance?		
Yes	535	97.3
No	15	2.7
Have you heard about multidrug resistance organisms?		
Yes	344	62.5
No	206	37.5
Have you heard about antimicrobial stewardship?		
Yes	298	54.2
No	252	45.8
Antimicrobial resistance is a global problem		
Yes	535	97.3
No	0	0
I don't know	15	2.7
Antimicrobial resistance is a problem for medical students		
Yes	355	64.7
No	135	24.5
I don't know	60	10.9
Which microorganism is sensitive to antibiotics?		
Bacteria	392	71.2
Viruses	112	20.4
Fungi	54	9.8
Antimicrobial resistance is the ability of the organisms o grow in presence of drugs that will normally kill or inhibit their growth		
Yes	386	70.2
No	52	9.4
I don't know	112	20.4
How long should a patient take antibiotics?		
When symptoms stop	120	21.8
As prescribed by the physician	430	78.2

Knowledge of antibiotic use and resistance:
 Participants were required to respond to questions that assessed their knowledge

about antibiotic use and resistance. About 97.3%, 62.5%, and 54.2% indicated that they have heard of the terms 'antibiotic resis-

tance', 'multidrug drug resistance' and 'anti-microbial stewardship' respectively. Among the study participants, 97.3% agreed that it was a global problem. However, only 64.7% felt that it is a problem for medical students. Surprisingly, 20.4% indicated that viruses are sensitive to antibiotics. Among the study participants, 70.2% knew that antimicrobial resistance is the ability of the organisms to grow in the presence of drugs that would normally kill or inhibit their growth. The results are

reflected in Table 2.

When comparing the responses across the years of study, the percentage of students with knowledge of AMU and AMR increased progressively with the years of study, 39.0% of students in the 1st and 2nd year, 58.0% in the 3rd year, 85.0% in the 4th year, 95.0% in the 5th year and 99.0% in the 6th year, had knowledge of AMR and AMS (Fig 1).

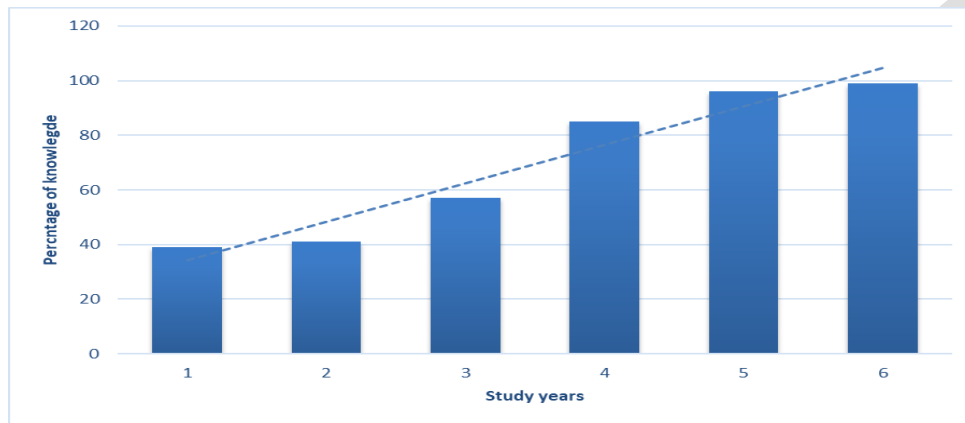


Fig 1: The trend in knowledge of AMR and AMS according to year of study

Table 3: Habits of the medical students to antibiotics use

Question	Frequency of response	Percentage
I consult a doctor before starting antibiotics		
Always	122	22.2
Sometimes	391	71.1
Never	54	6.7
I go for laboratory test before commencing		
Always	32	17.1
Sometimes	230	41.8
Never	248	45.1
I take antibiotics anytime I have fever		
Always	498	90.5
Sometimes	52	9.5
Never	0	0
I stop antibiotics when I feel better or the symptoms stop		
Always	311	56.5
Sometimes	130	23.6
Never	109	19.8
I keep the remaining/leftover antibiotics for future use after recovery		
Always	349	63.5
Sometimes	142	25.8
Never	59	10.7
I give the remaining/leftover antibiotics to a friend when he/she falls sick		
Always	39	7.1
Sometimes	111	20.2
Never	400	72.2
I take antibiotics when I have catarrh and/or cough		
Always	327	59.5
Sometimes	192	34.9
Never	31	5.6

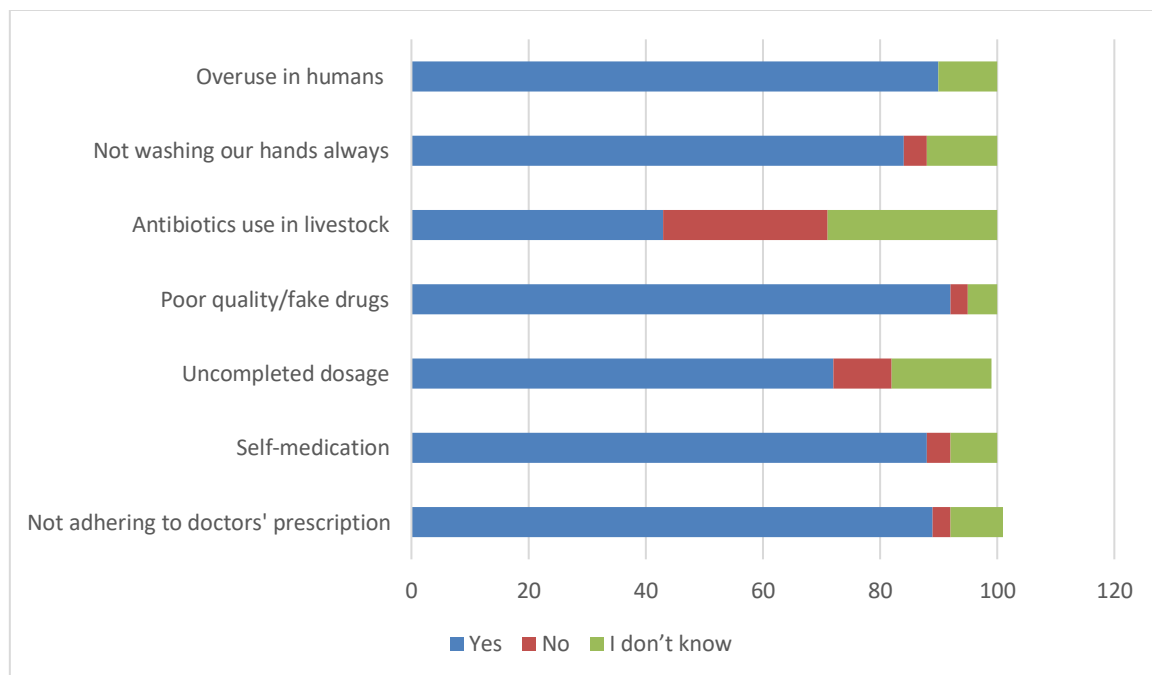


Fig 2: Knowledge of factors responsible for emergence of antimicrobial resistance

Habits of students to antimicrobial use:

Regarding the habits of antimicrobial use by the respondents, only 22.2% always consult a doctor before starting an antibiotic, 13.1% go for laboratory tests, and 90.5% always take antibiotics anytime they have a fever. Above half of the respondents (56.5%) do not complete the dosage of the antibiotics while 63.5% keep leftover antibiotics for future use. Surprisingly, above half (59.5%) of the respondents always take antibiotics when they have cough and or catarrh (Table 3).

Knowledge of factors responsible for emergence of antimicrobial resistance:

In assessing the factors responsible for emergence of AMR, 88.8% indicated not adhering to a doctor's prescription, 92.0% indicated that poor quality of drugs could cause resistance, 88.4% noted self-medication, and 89.6% indicated that overuse of antimicrobials in human can cause AMR. However, only 42.8% of students knew that over use of antibiotics in livestock as the cause of AMR (Fig 2).

Discussion:

Antimicrobial resistance has become a greater concern globally (13), with the bulk of the burden occurring in sub-Saharan Africa, including Nigeria (14). Promoting responsible antimicrobial use has become a crucial step in reducing antimicrobial resistance, and healthcare professionals are involved in antibiotic prescribing, dispensing, administering,

and usage. This study provides valuable insights into the knowledge of AMR and habit of antibiotic use among medical students of the University of Nigeria Enugu. A high response rate (91.36%) was obtained from this study, which may be because the researchers were mainly medical students who are passionate about AMR, who therefore facilitated wide distribution and collection of questionnaires, despite the different locations of the three UNN campuses.

In this study, majority of the study participants (97.3%) have heard about AMR, but only slightly more than half of them (54.2%) have heard about the term 'antimicrobial stewardship'. Antimicrobial stewardship is rapidly evolving and involves a set of interventions that promote responsible antimicrobial use. Surprisingly, a study done in three medical schools in the United States reported that only 40% (115 of 288) of the respondents were familiar with AMS (15). It is believed that knowledge of AMR in developing countries should be vast, but this report has clearly shown that the lack of knowledge in AMS spans across countries. The majority (97.3%) of the study participants responded that AMR is a global problem. This agrees with previous studies conducted among medical students in Nigeria (16) and Peru (17), where 98.4 % and 98.0% of the respondents, respectively stated that AMR was a global problem. Although, majority of the participants responded that AMR is a global problem, 64.7% of them seem to underestimate that this problem can affect them. In a study

by Dyar et al (14), and Brink et al (18), a good number of students indicated that it is only a national problem. Similarly, a study conducted in France and Scotland among junior doctors reported that 95% indicated that it is a national problem, but only 63.0% believed that it could affect their practice (7).

About 71.3% knew that bacteria are sensitive to antibiotics and 70.2% indicated that AMR is the ability of the organisms to grow in the presence of drugs that would normally kill or inhibit their growth. More so, 21.8% indicated that antibiotics should be stopped when the clinical symptoms subside while 78.2% responded that they should be guided by doctors' prescriptions. When antibiotics are wrongly used, it induces 'selection pressure' among the bacteria and promotes AMR. We observed that the overall knowledge level of the study participants increased with the year of study. This is in accordance with previous studies that observed that students who were in the final years of study had better knowledge than others (19,20). The plausible explanation is that AMS has been included in the curriculum of older students. Additionally, these students have completed their clinical rotations with improved knowledge of prescription habits and antimicrobial use (19,20). This finding underscores the significance of education and awareness in fostering responsible antibiotic use in the early stages of training of medical students.

Although the knowledge of AMR was high among the participants in our study, it was evident that this did not reflect in the habits of antibiotic use in their regular lives. This is shown by the proportion of students (90.5%) who always use antibiotics whenever they have a fever and 59.5% use them for the management of cough and catarrh. This habit may be because of the lack of knowledge of the students concerning rational antibiotic use and this is disastrous because it will reflect in their antibiotic prescription patterns during practice, affecting the general well-being of the population (21,22). This is in agreement with studies by Efthymiou et al., (23), and Nisabwe et al., (20), who reported that the majority of their participants claimed that antibiotics are used for treating viral infections and common flu. A systematic review of antibiotic use for common cold and acute purulent rhinitis reported there is no benefit in taking antibiotics for common cold, sore throat, and cough (24). This is because these infections are mostly caused by viruses, and antibiotics do not affect them.

Only 22.2% of the students in our study always seek doctors' advice before taking antibiotics. In a study conducted in Nigeria, antibiotics were among the top three medications used for self-medication among un-

dergraduate healthcare students (9). A higher rate was obtained in a survey conducted among students in Ghana (25) and India (5), where 79.2% and 71.6% of students respectively, used antibiotics prescribed by doctors. Self-medication is a major contributor to AMR and it is worse when it is not guided by laboratory results. Only 13.1% of the students indicated that they always go for laboratory tests before commencing antibiotics.

About 56.5% of the students reported not always completing the dose of the antibiotics and stopping therapy when symptoms subside. Also, 63.5% always keep the leftover drugs for future use, among whom 7.1% give leftover to their friends when they fall sick. These are bad habits that promote inappropriate antimicrobial use (wrong drug, wrong dose, non-adherence or unnecessary antimicrobials) that contributes to the emergence and spread of AMR. Understanding the factors that promote emergence and spread of AMR, participants identified poor hand hygiene practices, not adhering to prescriptions (88.8%), poor drug quality (92.0%), and self-medication (88.4%). Surprisingly, the proportion that indicated overuse of antibiotics in livestock was the least (42.8%). This suggests that training and awareness of the contributors from other sectors (animal and environment) in AMR are imperative. The WHO has highlighted the importance of an integrated and holistic multisectoral 'One Health' approach in combating AMR (26).

This study presents several strengths. Firstly, the large sample size used in the study shows the accuracy of the result. Secondly, the study cuts across students in different years of study, opening up the gap in the training of the younger medical students. Thirdly, the voluntary and anonymous nature of the survey reduced the possibility of the study participants providing "socially desirable" answers. However, a major limitation of the study is its unicentric nature, necessitating a survey that will involve more centres.

Conclusion:

This survey has identified knowledge gaps in AMR/AMS education and training which underscores the importance of targeted interventions to bridge the knowledge gaps among medical students, especially in the early phase of their academic and professional training. Improving adherence to proper antibiotic use and addressing misconceptions, such as antibiotics' effectiveness against viruses, among others, are crucial steps in combating AMR. Education and awareness campaigns tailored to specific cohorts can contribute to more responsible antibiotic use and a better understanding of the global challenge

of antibiotic resistance.

Contributions of authors:

NI, NS, IP, AK, NS, ES and OO conceptualized and designed the study; NI, IF, NL, NS, OO, ER and NL were involved in data collection; PG, ES, IF, ON, NS, ER, NL and AK performed data analysis; IP, NS, ES, NI, PG, IP and ON wrote the manuscript. All authors approved the final manuscript submitted for publication.

Source of funding:

No funding was received for the study

Conflict of interest:

Authors declare no conflict of interest

Previous presentation:

Oral presentation of this paper was made at the 3rd CLIMIDSON virtual conference held between November 23-24 2023 and the abstract was published in the conference brochure.

References:

- World Health Organization. Antimicrobial resistance Media Centre; 2018. <http://www.who.int/mediacentre/factsheets/fs194/en/>. (Accessed December 1, 2023).
- Rice, L. B. Federal funding for the study of antimicrobial resistance in nosocomial pathogens: No ESKAPE. *J Infect Dis.* 2008; 197 (8): 1079–1108. doi:10.1086/533452.
- Cusini, A., Rampini, S. K., Bansal, V., et al. Different patterns of inappropriate antimicrobial use in surgical and medical units at a tertiary care hospital in Switzerland: a prevalence survey. *PLoS One.* 2010; 5 (11): e1401. doi:10.1371/journal.pone.0014011
- World Health Organization. Antimicrobial Resistance. 2020. <https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance>. (Accessed December 1, 2023).
- Khan, A. K., Banu, G., and Reshma, K. K. Antibiotic resistance and usage—a survey on the knowledge, attitude, perceptions and practices among the medical students of a southern Indian teaching hospital. *J Clin Diagn Res.* 2013; 7: 1613–1616. doi:10.7860/JCDR/2013/6290.3230.
- Moongtui, W., Picheansathian, W., and Senaratan, W. Role of nurses in prevention of antimicrobial resistance. *Reg Health Forum.* 2011; 15 (1): 104–111.
- Pulcini, C., Williams, F., Molinari, N., Daveyc, P., and Nathwani, D. Junior doctors' knowledge and perceptions of antibiotic resistance and prescribing: a survey in France and Scotland. *Clin Microbiol Infect.* 2011; 17 (1): 80–87. doi:10.1111/j.1469-0691.2010.03179.x.
- Heaton, A., Webb, D. J., and Maxwell, S. R. Undergraduate preparation for prescribing: the views of 2413 UK medical students and recent graduates. *Br J Clin Pharmacol.* 2008; 66 (1): 128–134. doi:10.1111/j.1365-2125.2008.03197.x.
- Akande-Sholabi, W., and Ajamu, A. T. 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: 488. doi:10.1186/s12909-021-02912-4.
- Mudenda, S., Mukela, M., Matafwali, S., et al. Knowledge, Attitudes, and Practices towards Antibiotic Use and Antimicrobial Resistance among Pharmacy Students at the University of Zambia: Implications for Antimicrobial Stewardship Programmes. *Sch Acad J Pharm.* 2022; 11: 117–124. doi:10.36347/sajp.2022.v11i08.002
- Dyar, O. J., Pulcini, C., Howard, P., and Nathwani, D. ESGAP (ESCMID Study Group for Antibiotic Policies). European medical students: A first multicentre study of knowledge, attitudes and perceptions of antibiotic prescribing and antibiotic resistance. *J Antimicrob Chemother.* 2014; 69: 842–846. doi:10.1093/jac/dkt440.
- World Health Organization. Global Action Plan on Antimicrobial Resistance. World Health Organization; Geneva, Switzerland: 2015.
- Spellberg, B., Gidycz, R., and Gilbert, D. The epidemic of antibiotic resistant infections: A call to action for the medical community from the Infectious Diseases Society of America. *Clin Infect Dis.* 2008; 46 (2): 155–164. doi:10.1086/524891.
- Dyar, O., Howard, P., Nathwani, D., and Pulcini, C. Knowledge, attitudes, and beliefs of French medical students about antibiotic prescribing and resistance, *Médecine et Maladies Infectieuses.* 2013; 43 (10): 423–430. doi:10.1016/j.medmal.2013.07.010
- Abbo, L. M., Cosgrove, S. E., Pottinger, P. S., et al. Medical Students' Perceptions and Knowledge About Antimicrobial Stewardship: How Are We Educating Our Future Prescribers? *Clin Infect Dis.* 2013; 57 (5): 631–638. <https://doi.org/10.1093/cid/cit370>
- Okedo-Alex, I., Madubueze, U. C., Umeokonkwo, C. D., Oka, O. U., Adeke, A. S., and Okeke, K. C. Knowledge of antibiotic use and resistance among students of a medical school in Nigeria. *Malawi Med J.* 2019; 31(2): 133–137. doi:10.4314/mmj.v31i2.5
- García, C., Llamocca, L. P., García, K., et al. Knowledge, attitudes and practice survey about antimicrobial resistance, and prescribing among physicians in a hospital setting in Lima, Peru. *BMC Clin Pharmacol.* 2011; 11 (1): 18. doi:10.1186/1472-6904-11-18.
- Brink, A., Schoeman, J., and Muntingh, G. Undergraduate antibiotic stewardship training: Are we leaving our future prescribers 'flapping in the wind'? *S Afr Med J.* 2017; 107: 357–358. doi:10.7196/SAMJ.2017.v107i5.12496.
- Hagiya, H., Ino, H., Tokumasu, K., et al. Antibiotic literacy among Japanese medical students. *J Infect Chemother.* 2020; 26: 1107–1109. doi:10.1016/j.jiac.2020.06.021
- Nisabwe, L., Brice, H., Umuhire, M. C., et al. Knowledge and attitudes towards antibiotic use and resistance among undergraduate healthcare students at University of Rwanda. *J Pharm Policy Pract.* 2020; 13: 7 <https://doi.org/10.1186/s40545-020-00207-5>
- Haenssger, M. J., Xayavong, T., Charoenboon, N., Warapikuptanun, P., and Khine, Y. The consequences of AMR education and awareness raising: outputs, outcomes, and behavioural impacts of an antibiotic-related educational activity in Lao PDR. *Antibiotics.* 2018; 7 (4): 95. doi:10.3390/antibiotics7040095.
- Ghiga, I. No time to wait: securing the future from drug-resistant infections. Report to the Secretary-General of the United Nations. 2019.
- Efthymiou, P., Gkentzi, D., and Dimitriou, G. Knowledge, Attitudes and Perceptions of Medical Students on Antimicrobial Stewardship. *Antibiotics (Basel).* 2020; 9 (11): 821. doi:10.3390/antibiotics9110821.
- Kenealy, T., and Arroll, B. Antibiotics for the common cold and acute purulent rhinitis. *Cochrane Database of Syst Rev.* 2013; 2013 (6): CD000247. doi:10.1002/14651858.CD000247.pub3.
- Owusu-Ofori, A. K., Darko, E., Danquah, C. A., Agyarko-Poku, T., and Buabeng, K. O. Self-Medication and Antimicrobial Resistance: A Survey of Students Studying Healthcare Programmes at a Tertiary Institution in Ghana. *Front Publ Health.* 2021; 9: 706290. doi:10.3389/fpubh.2021.706290.
- Robinson, T., D., Bu, J., Carrique-Mas, E., et al. Antibiotic resistance is the quintessential One Health issue. *Trans Roy Soc Trop Med Hyg.* 2016; 110: 377–380. doi:10.1093/trstmh/trw048