Knowledge and Perceptions of Antimicrobial Stewardship Concepts Among Final Year Veterinary Students in South Africa

Linè Fick ■ Lucille Crafford ■ Johan Schoeman ■ Natalie Schellack

ABSTRACT

Antimicrobial resistance (AMR) has become a major global public health crisis due to inappropriate use in humans, animals, and crops. Studies to assess the knowledge and perceptions of antimicrobial stewardship (AMS) practices among medical and health care professionals have been conducted, yet this is the first among veterinary students in South Africa. A descriptive study surveyed 147 final year veterinary students at the Faculty of Veterinary Science, University of Pretoria. Of these, 102 completed the questionnaire (69% response rate). Most stated they knew what AMS was, while a minority heard of it for the first time. A small number understood poor hand washing could contribute to AMR. Almost a quarter of students stated their AMS knowledge was poor, and most noted a need for more training. The BVSc curriculum should include more material on AMS and AMR to bridge training gaps.

Key words: antimicrobial stewardship, antimicrobial resistance, veterinary education, South Africa, prescribers, pharmacology, infectious disease

INTRODUCTION

It is well known that antimicrobial resistance (AMR) is a global threat.[1] AMR has been linked to the excessive use of antimicrobials in one of the following three sectors, human, animal, and environmental.[2] The interplay between humans and animals is highlighted by the similarity of acquired antibiotic resistance genes (ARGs) between humans and animals.[3] Some factors that drive AMR transfer between these three components, have been identified, for example, the misuse and overuse of antimicrobials; lack of access to clean water, sanitation and hygiene (WASH).[3] Thus, the collaboration between these three sectors cannot be overstated and is currently done using the "*One Health*" approach.[2,3]

The One Health approach has its inception in the 19th century, when Rudolf Virchow introduced the term "Zoonosis," which encompasses the relationship between human and animal health.[2] The One Health approach is further defined as a joint effort of various disciplines that come together to provide solutions for human, animal, and environmental health [One Health High-Level Expert Panel (OHHLEP)].[4] Despite this well-defined approach, the fundamental knowledge of the interplay between these three sectors is seemingly not yet well understood nor elucidated globally, most notably in low- and middle-income countries (LMICs).[5]

A set of guidelines was published by the International Committee of the World Organization for Animal Health (OIE) in 2003 for all OIE Member Countries relating to the public health risks of AMR, originating from the use of antibiotics in veterinary medicine.[6] The OIE guidelines were used to develop technical guidelines for the responsible and appropriate use of antimicrobials in veterinary medicine in South Africa.[6] South Africa launched the "Antimicrobial Resistance National Strategic Framework, 2014–2024 (AMR Strategic Framework)" in 2014, with the commitment of most of the key stakeholders within the human and animal health, agriculture, as well as science and technology sectors. The AMR National Strategy framework encompasses veterinary antimicrobial stewardship (AMS). The purpose of the framework is to offer a structure for managing AMR, preventing further development of resistant bacteria and to improve outcomes of patients.[8]

One of the key enablers of the National AMR Strategy Framework is to ensure education of all levels of health providers in human health, animal health, agriculture and industry in the critical concepts of AMS, infection control, infectious diseases, microbiology and pharmacology.[7] There have been studies conducted in South Africa (SA) evaluating the knowledge and perceptions of AMS practices in health care and medical students, but there seems to be a paucity in veterinary students.[9–11] Collectively, these studies identified gaps in the stewardship, knowledge and perception toward antimicrobial usage and advocated for more focused training.

The South African regulations currently ban the dispensing of antibiotics in pharmacies without a prescription. Antibiotics should only be dispensed with a valid prescription signed by an authorized prescriber such as a veterinarian who may prescribe, compound or dispense.[12] The University of Pretoria, is currently the only institution offering a degree in Veterinarian Sciences, with aspects of AMS included in its curriculum. The students are exposed to other educational activities, including a One Health rotation, thus they are exposed to AMS in a formal and informal way.

The research hypothesized that there is a lack of understanding of AMR and AMS concepts, and training should be enhanced

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to bridge the gap. Consequently, this study sets out to investigate knowledge gaps, attitudes and perception of future South-African veterinarians in the use of antimicrobials with a view to identify and bridge training gaps. With this information, appropriate recommendations can be provided to amend and increase AMR content in the current curriculum. Newly qualified veterinarians would be equipped with the necessary knowledge to help curb the growth of AMR in animals and ultimately in humans.

METHODS

Study Design and Population

A quantitative, descriptive survey was conducted to explore the knowledge, attitudes and perceptions of final year veterinary students on AMS concepts. A self-report questionnaire was sent to all 147 final year veterinary science students at the University of Pretoria, via email and WhatsApp. Data was collected over an 8-week period (May–June 2020), with reminder emails/WhatsApp messages sent bi-weekly in order to increase the response rate.

Educational Context

In South Africa, the University of Pretoria's Faculty of Veterinary Science at Onderstepoort is the only institution responsible for educating veterinary professionals. Students must obtain a 6-year Bachelor of Veterinary Science (BVSc) qualification, taught in English, before embarking on a compulsory Community Service year.

Data Collection and Data Collection Instrument

An electronic questionnaire (uploaded as Appendix 1) with response options was used to evaluate the final year veterinary students' knowledge, attitudes, and perceptions regarding AMS. The survey, piloted anonymously on 10 fifth year BVSc students, covered themes such as background knowledge, perceptions, attitudes toward prescribing and resistance, knowledge of AMS goals and strategies, and the quality and quantity of AMS education. The data collected in the pilot study was excluded from the main study. The questionnaire was adapted from a similar survey performed on final year pharmacy students by Burger et al.[9] and Abbo et al.[13] AMS was not defined in the questionnaire.

Limitations identified post-hoc included inadequate definitions of AMS and AMR for responders. The researchers were mindful not to sensitize the respondents before the study, so this limitation may have impacted the results, but not necessarily the main conclusions. Almost all students recognized their lack of readiness for future AMS tasks, thus the curriculum must include a module on AMS. Additionally, continuing education for veterinarians should focus on AMS, as well as investigate the effectiveness of continuous learning systems in maintaining knowledge and competencies related to AMS.

Data Analysis

Microsoft Excel was used to analyze data in combination with the result analysis function of Survey Monkey and exported to IBM Statistical Analysis Software (SAS) for analysis. Frequencies and percentages were calculated for all variables. Statistical significance was set at $p \leq .05$.

Ethical Considerations

Ethical approval was obtained from Sefako Makgatho University Research Ethics Committee (SMUREC/P/298/2018), as well as from the University of Pretoria's faculty of Veterinary Science and the faculty of Health Sciences (REC145–19). Participation was voluntary and responses remained anonymous.

RESULTS

Response Rate

One hundred and two of the 147 students (69% response rate) participated in the survey with a 92% (94, $n = 102$) completion rate.

Student Demographics

Overall, 66% (65; $n = 99$) of the respondents were female, whilst 71% (70; $n = 99$) of the students were between the ages of 22 and 25 years.

Background Knowledge on Antimicrobial Stewardship

Seventy-eight percent of respondents learned about AMS at university during their BVSc studies. Twelve percent were unaware of AMS before completing the study questionnaire, and 10% heard about it elsewhere (e.g., online articles, from clinicians, at congresses, or at work).

Perceptions and Attitudes About Antimicrobial Prescribing and Resistance

Table 1 reveals that 94% of students believe antimicrobials are inappropriate for animal use, 78% think AMS programs are necessary in SA, and almost all (97%–98%) think AMS comprises appropriate selection, dosing, route, and duration. Yet only 44% feel AMS requires antimicrobial research.

Table 2 presents the responses of final year veterinary students on questions regarding their perceptions and attitudes towards AMR. Most (98%) agreed that AMR is a universal issue in all health sectors and that its promotion in animals is due to overuse of antimicrobials (100%). Additionally, 89% considered that broad spectrum antimicrobial usage when narrow spectrum is available to be another factor. Poor handwashing practice (9%) and sub-standard quality medicine (29%) were thought to contribute too. Most (78%) proposed antimicrobial usage policies and the reduction of antimicrobial use in animal feeds and water (78%) as possible interventions to reduce AMR. 73% and 71% proposed the development of institutional guidelines for antimicrobial use and reduction in metaphylaxis use, respectively. 84% and 86% supported the reduction of

Table 1: Answer choices on what students thought antimicrobial stewardship involves

Answer choices	Responses (%) ($n = 97$)
The prescribing and use of antimicrobials are not inappropriate in animals only	91 (94%)
Implementation of AMS programs are essential in SA	76 (78%)
Appropriate selection of antimicrobials	94 (97%)
Appropriate dosing and route of administration	84 (87%)
Appropriate duration of antimicrobial therapy	91 (94%)
The study of antimicrobials	43 (44%)

Table 2: Perceptions and attitudes of final year veterinary students regarding antimicrobial prescribing and resistance

Answer choices regarding perceptions and attitudes about antimicrobial prescribing and resistance	Responses (%)
AMR is a worldwide problem in all health sectors (n = 94)	92 (98%)
The following promotes AMR in animals (n = 94)	
• Wide spread/overuse of antimicrobials	94 (100%)
• Usage of broad-spectrum antimicrobials when narrow spectrum is available	84 (89%)
• Poor hand washing practice	8 (9%)
• Sub-standard quality of antimicrobials	27 (29%)
Interventions that could possibly combat AMR in animals (n = 94)	
• Antimicrobial usage policies	73 (78%)
• Reduction of antimicrobial use	79 (84%)
• Reduction of antimicrobial use in animal feeds and water	73 (78%)
• Reduction of antimicrobial use to increase growth in livestock	60 (64%)
• Establish national antimicrobial resistance surveillance	59 (63%)
• Development of institutional guidelines for antimicrobial use	69 (73%)
• Education on antimicrobial therapy for prescribers and users	81 (86%)
• Reduction in usage of control treatment (metaphylaxis) (treatment of the whole group of animals after the diagnosis of an infection and/or clinical disease in part of the group)	67 (71%)
Inappropriate use of antimicrobials in animals can harm people (n = 93)	93 (100%)
Better use of antimicrobials will reduce problems with antimicrobial resistance (n = 94)	93 (99%)
Prescribing antimicrobials responsibly is one of the responsibilities of a veterinarian (n = 94)	92 (98%)
The role of the veterinarian in AMS includes the following (n = 92)	
• Promoting optimal use of antimicrobial agents	77 (84%)
• Prescribing appropriate antimicrobial agents	90 (98%)
• Educating other healthcare professionals	60 (65%)
• Working with therapeutic committees to develop policies	53 (58%)

Table 3: Perceptions of final year veterinary students on their education on antimicrobial stewardship

Answer choices regarding education on AMS	Responses (%)
Received formal training on AMS (n = 91)	38 (42%)
How many hours of AMS education received in the last year (n = 91)	
• 0 hours	29 (32%)
• 1–4 hours	56 (62%)
• 5–7 hours	5 (5%)
• 8 hours or more	1 (1%)
Would like more training on AMS (n = 91)	82 (90%)
Rating of knowledge on AMS (n = 91)	
• Poor	22 (24%)
• Average	53 (58%)
• Good	17 (19%)
• Very good	1 (1%)
Area of training that the student acquired most of their knowledge of AMS (n = 73)	
• No specific area	3 (4%)
• Private practice	1 (1%)
• During the theoretical component of the BVSc program	13 (18%)
• Clinical training	46 (63%)
• Pharmacology	18 (25%)
What can be done to improve AMS in the animal health sector in SA (n = 74)	
• Self-education	17 (23%)
• Inclusion of AMS into the curriculum	6 (8%)
• Rational antimicrobial prescription	38 (51%)
• Education of others	14 (19%)

antimicrobial use and education about therapeutic use, respectively. 64% and 63% proposed reduction of antimicrobial use to increase animal growth and establishing national AMR surveillance. All (100%) agreed that improper use of antimicrobials in animals can harm humans, that better antimicrobial use will reduce AMR issues (99%), and that it is the veterinarian's responsibility to prescribe antimicrobials responsibly (98%). The majority (98%) stated that responsible prescribing is one of the veterinarian's roles in AMS, and 84% said promotion of optimal antimicrobial use is another. 65% gave educating other healthcare professionals as a role, and 58% said working with therapeutic committees to develop policies.

Education on Antimicrobial Stewardship
Almost half (42%) of the final year veterinary students surveyed reported receiving formal AMS education in the last year, and 62% reported up to 4 hours. Only 5% received 5–7 hours education, with one student exceeding 8 hours. This data, summarized in Table 3, further indicates that 90% of the students would like more AMS training, 58% gauging their knowledge as average, while 24% perceiving it as poor.

Twenty-five percent of students say they learned most of their AMS knowledge in pharmacology lectures, 63% in clinical training, and 18% generally through their BVSc degree. 8% acquired knowledge in small animal training, production clinic training, or equine medicine. To improve AMS, 51% said they'd practice rational antimicrobial prescription, 23% said they'd educate themselves, 19% said others should, and 8% said more AMS concepts should be included in the BVSc curriculum.

DISCUSSION
This study evaluated the knowledge and perceptions of South African final year veterinary students on AMS concepts. Nearly 70% of all students participated in the survey, with a completion rate of 92%.

Most students were familiar with the concept of AMS, but only a small number were aware of existing AMS programs in South Africa. A minority of students had never heard of AMS before the study. Despite this, most students believed these programs should be implemented. Similar results were found in other countries in Africa during a study of final year veterinary students, emphasizing that the knowledge gap observed elsewhere is present in South Africa.[14]

The majority of students believe AMS is selecting the right antimicrobial, but only half agreed it included studying them. Most also agreed it covers dosing, administration and duration of treatment. It also involves limiting use of antibiotics where necessary.[15] AMS is *"the best clinical outcome with low harm and minimal resistance impact"*[16] or *"the action of veterinary professionals in preserving the effectiveness and availability of antimicrobials while safeguarding animal, public and environmental health"*.[16] A study of Nigerian veterinary schools identified major gaps in AMR and AMS knowledge,[17] mirroring findings in South African pharmacy and medical students.[9,11] These findings signal an urgent need to improve antimicrobial perceptions across the continent and among healthcare disciplines, and that the *"One Health"* approach applies to all professions in the call for rational use of antimicrobials.

The study showed that students believed reducing antimicrobial use and improving education on its use are key interventions towards reducing AMR, which aligns with a systematic review that assessed the impact of educational interventions on prescribing and dispensing antibiotics.[18] Moreover, all students agreed that misusing antibiotics in animals can be harmful to humans. Comparatively, in a similar study on veterinary students in Serbia and Croatia, only 56.8% were aware of this fact.[19] Additionally, given the significant economic and dietary changes over the past 15 years in LMICs, there has been a major increase in antimicrobial use, which increases the risk of inappropriate use, leading to negative health impacts.[20]

Final year veterinary students believe overuse of antimicrobials can lead to AMR in animals and a small percentage stated that poor handwashing practices can contribute to this issue. Hand hygiene is crucial for preventing infection; inadequate hand washing can lead to respiratory tract infections and acute diarrheal diseases necessitating the use of antibiotics.[21] Thus, personal protective equipment (PPE) and hand hygiene should be emphasized in veterinary curriculum to reduce the risk of zoonotic pathogens.[21]

Almost all students agreed that a veterinarian's role in AMS involves prescribing antibiotics while promoting their optimal use. South Africa's government has implemented initiatives to limit antibiotic use in intensive farming, such as tightening regulation of colistin in broiler chickens. This is reflected in a study conducted among Australian veterinary students, which found that incorrect prescribing and administering of antibiotics, particularly in food animals, significantly contribute to the development of antibiotic resistance.[22]

The majority of students indicated a need for more training on AMS, supporting that more than half of the students thought their knowledge of AMS was average, and almost a quarter of the students thought their knowledge was poor. Studies in South Africa,[9] Nigeria,[17] Ethiopia,[23] Europe,[24] Australia,[22] and South-eastern Europe[19] have all reported a need for more training on AMS.[19] In addition, the need for a structured AMS curriculum for veterinary students in SA was also emphasized by Brink et al.[25]

Our findings revealed that 25% of students indicated that they learned about AMS through pharmacology lectures and nearly half through clinical training. A similar study in Australia found that clinical teaching of antimicrobial use was not always consistent with preclinical teaching, with 32% of students reporting that clinical training was more beneficial. However, when comparing two cohorts of graduates, those with higher exposure to clinical teaching had lower levels of compliance with guidelines, suggesting preclinical teaching is superior.[22] As we did not investigate this topic further, efforts should be made to ensure consistency in pre- and clinical teaching with a focus on appropriate utilization of guidelines. Further research is needed to explore the implementation of guidelines in veterinary practice.

This study has strengths and limitations. It was strengthened by the use of an anonymous questionnaire, which likely captured the knowledge of veterinary students when they graduate. This gives insight into the current knowledge and perception of AMS among veterinary students. The results, then, suggest that educating veterinary students on AMS is important. Therefore, the authors recommend making efforts to address educational gaps in their training.

This study adds value to veterinary antimicrobial stewardship practice, especially in low-income and middle-income countries. Clinical training and experience during training mainly shape knowledge and perceptions of antimicrobial stewardship, while theoretical knowledge is imparted through coursework. This information can guide faculty to include antimicrobial stewardship-related course content between preclinical and clinical training, as most students requested it.

This study was limited to the Veterinary Science Faculty in South Africa, the only one of its kind in the country. Its small sample size from one University may not be representative of the whole South Africa, but it provides a basis for further investigation. Moreover, it was only conducted with final year students, so it does not offer representative results from all levels of the curriculum.

Antibiotic prescribing is a complex social process involving different stakeholders whose opinions are shaped by multiple factors, such as the influence of peers or hierarchical structures within clinical teams. It is also impacted by different views on prescribing practices, as well as access to policies and guidelines, availability of surveillance processes and education and training for AMS teams and other healthcare workers.

CONCLUSION

Veterinary students in their final year indicated a need for more formal training in AMS concepts. A possible solution for this is to include formal and practical material on AMS and AMR in the BVSc curriculum, such as handwashing according to IPC principles. Further research is needed into the implementation of guidelines in the profession, and into the efficacy of the current continuous education system in improving the knowledge and competencies of veterinarians in relation to AMS. Pre-clinical and clinical integration of AMS-related material could also be beneficial.

DISCLOSURES

REFERENCES

1. Larkin H. Increasing antimicrobial resistance poses global threat, WHO says. JAMA. 2023;329(3):200. https://doi.org/10.1001/jama.2022.23552.

2. Velazquez-Meza ME, Galarde-López M, Carrillo-Quiróz B, Alpuche-Aranda CM. Antimicrobial resistance: One Health approach. Vet World. 2022;15(3):743–9. https://doi.org/10.14202/vetworld.2022.743-749. PMID: 35497962

3. Cao H, Bougaffa S, Park T, Lau A, Tony M, Chow P. Sharing of antimicrobial resistance genes between humans and food animals. Am Soc Microbiol. 2022;7(6):e0077522. https://doi.org/10.1128/msystems.00775-22. PMID: 36218363

4. One Health High-Level Expert Panel (OHHLEP); Adisasmito WB, Almuhairi S, Behravesh CB, et al. One Health: a new definition for a sustainable and healthy future. PLoS Pathog. 2022; 23;18(6):e1010537. https://doi.org/10.1371/journal.ppat.1010537. PMID: 35737670.

5. Van Boeckel TP, Pires J, Silvester R, et al. Global trends in antimicrobial resistance in animals in low- and middle-income countries. Science. 2019;365(6459):eaaw1944. https://doi.org/10.1126/science.aaw1944. PMID: 31604207

6. OIE strategy on antimicrobial resistance and the prudent use of antimicrobials. 2016. Available at: https://www.oie.int/fileadmin/Home/eng/Media_Center/docs/pdf/PortailAMR/EN_OIE-AMRstrategy.pdf.

7. National Department of Health. South African antimicrobial resistance strategy framework. 2017. Available at: https://www.health-e.org.za/wp-content/uploads/2015/09/Antimicrobial-Resistance-National-Strategy-Framework-2014-2024.pdf.

8. Departments of Health and Agriculture, Forestry and Fisheries for the Republic of South Africa. Antimicrobial resistance national strategy framework 2018–2024. 2018. Available at: http://www.health.gov.za/index.php/antimicrobial-resistance?download=3308:amr-national-action-plan-2018-2024.

9. Burger M, Fourie J, Loots D, et al. Knowledge and perceptions of antimicrobial stewardship concepts among final year pharmacy students in pharmacy schools across South Africa. 2016. Available at: https://www.sajei.co.za/index.php/SAJEI/article/download/791/964.

10. Smith PW, Agbaje M, LeRoux-Pullen L, et al. Implication of the knowledge and perceptions of veterinary students of antimicrobial resistance for future prescription of antimicrobials in animal health, South Africa. J S Afr Vet Assoc. 2019;90(0):e1–e8. https://doi.org/10.4102/jsava.v90i0.1765. PMID: 31714110

11. Wasserman S, Potgieter S, Shoul E, et al. South African medical students' perceptions and knowledge about antibiotic resistance and appropriate prescribing: are we providing adequate training to future prescribers? S Afr Med J. 2017;107(5):405–10. https://doi.org/10.7196/SAMJ.2017.v107i5.12370. PMID: 28492121

12. Schellack N, Benjamin D, Brink A, et al. A situational analysis of current antimicrobial governance, regulation, and utilization in South Africa. Int J Infect Dis. 2017;64(2017):100–106. https://doi.org/10.1016/j.ijid.2017.09.002. PMID: 28893672

13. Abbo LM, Cosgrove SE, Pottinger PS. Medical students' perceptions and knowledge about antimicrobial stewardship: how are we educating our future prescribers? Clin Infect Dis. 2013;57(5):631–8. https://doi.org/10.1093/cid/cit370. PMID: 23728148

14. Fasina FO, LeRoux-Pullen L, Smith P, et al. Knowledge, attitudes, and perceptions associated with antimicrobial stewardship among veterinary students: a multi-country survey from Nigeria, South Africa, and Sudan. Front Public Health. 2020;21;8:517964. https://doi.org/10.3389/fpubh.2020.517964. PMID: 33194938

15. Bankar NJ, Ugemuge S, Ambad RS, Hawale DV, Timilsina DR. Implementation of antimicrobial stewardship in the healthcare setting. Cureus. 2022;8;14(7):e26664. https://doi.org/10.7759/cureus.26664. PMID: 35949742.

16. American Veterinary Medical Association. Antimicrobial stewardship definition and core principles. Available at: https://www.avma.org/resources-tools/avma-policies/antimicrobial-stewardship-definition-and-core-principles.

17. Anyanwu MU, Okorie-Kanu OJ, Anyaoha CO, Kolade OA. Veterinary medical students' perceptions, attitude and knowledge about antibiotic resistance and stewardship: how prepared are our future prescribers? Not Sci Biol. 2018;10:156–74. https://doi.org/10.15835/nsb10210258.

18. Roque F, Herdeiro MT, Soares S, Teixeira Rodrigues A, Breitenfeld L, Figueiras A. Educational interventions to improve prescription and dispensing of antibiotics: a systematic review. BMC Public Health. 2014;14:1276. https://doi.org/10.1186/1471-2458-14-1276. PMID: 25511932

19. Kovacevic Z, Blagojevic B, Suran J, Horvat O. Mapping knowledge and comprehension of antimicrobial stewardship and biosecurity among veterinary students. PLoS One. 2020;15(8):e0235866. https://doi.org/10.1371/journal.pone.0235866. PMID: 32813747

20. Ahmad SI, Malak HA, Abulreesh HH. Environmental antimicrobial resistance and its drivers: a potential threat to public health. J Glob Antimicrob Resist. 2021;27:101–111. https://doi.org/10.1016/j.jgar.2021.08.001. PMID: 34454098

21. Verkola M, Järvelä T, Järvinen A, et al. Infection prevention and control practices of ambulatory veterinarians: a questionnaire study in Finland. Vet Med Sci. 2021;7(4):1059–70. https://doi.org/10.1002/vms3.464. PMID: 33645926

22. Hardefeldt L, Nielsen T, Crabb H, et al. Veterinary students' knowledge and perceptions about antimicrobial stewardship and biosecurity—a national survey. Antibiotics. 2018;7(2):34. https://doi.org/10.3390/antibiotics7020034. PMID: 29670064

23. Abera B, Kibret M, Mulu W. Knowledge and beliefs on antimicrobial resistance among physicians and nurses in hospitals in Amhara Region. Ethiopia. 2014;15:26. https://doi.org/doi:10.1186/2050-6511-15-26. PMID: 24887310

24. Dyar OJ, Pulcini C, Howard P. 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(3):842–6. https://doi.org/10.1093/jac/dkt440. PMID: 24191307

25. Brink A, Schoeman J, Muntingh G. Undergraduate antibiotic stewardship training: are we leaving our future prescribers 'flapping in the wind'? S Afr Med J. 2017;107(5):357–358. doi: 10.7196/SAMJ.2017.v107i5.12496. PMID: 28492112

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