

Knowledge and perceptions of antimicrobial stewardship concepts among final year pharmacy students in pharmacy schools across South Africa

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Background: Antimicrobial stewardship is currently not mandatory as part of the undergraduate training of pharmacists. Identifying gaps in knowledge and a better understanding of pharmacy students' perceptions about antimicrobial stewardship could assist in recommendations for appropriate changes to the pharmacy degree curricula that may lead to more appropriate use of antimicrobials, within the multi-disciplinary team.

Methods: A descriptive quantitative study with a survey design was conducted at the eight universities offering the pharmacy degree in South Africa. An electronic questionnaire with four main categories on antimicrobial stewardship was administered to final (fourth) year pharmacy students (June–August 2015).

Results: An overall response rate of 26.6% ($n = 260$) was obtained from 978 students, despite a weekly reminder. Most of the respondents were familiar with antimicrobial stewardship programmes in South Africa (71.9%), and claimed to know what antimicrobial stewardship is (83.5%) with significant differences between the universities ($p < 0.001$). Only 37.7% of the respondents recalled having had formal training on antimicrobial stewardship, with responses from the eight universities differing significantly ($p < 0.001$). However, almost all respondents (98.5%) felt that a strong knowledge of antimicrobials was important for their future career, with 90.0% indicating that they would like more training on antimicrobial stewardship at undergraduate level.

Conclusion: There were significant differences between the eight universities with regards to undergraduate education on antimicrobial stewardship. In order to help prevent antimicrobial resistance, efforts should be made to introduce concepts of antimicrobial stewardship into the undergraduate pharmacy curricula to promote better use of antimicrobials and prevent antimicrobial resistance.

Keywords: antimicrobial resistance, antimicrobial stewardship, education, pharmacy students

Introduction

Antimicrobial resistance is an increasingly important patient safety and public health issue.^{1,2} Emergence and spread of resistance is linked to antimicrobial exposure, both in the population and at an individual level.¹ According to the World Health Organisation, antibacterial resistance surveillance has not been standardised, and techniques for data collection pertaining to resistance has not been refined.³ The common bacteria responsible for infections in both the hospital and community settings include *Escherichia coli*, *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Enterococcus faecium*, *Acinetobacter baumannii*, *Enterobacter cloacae*, non-typhoidal *Salmonella*, *Shigella spp.* and *Neisseria gonorrhoea*.³ Infections caused by resistant microorganisms often fail to respond to the standard treatment, resulting in prolonged illness and greater risk of death.¹ An important key measure to prevent and reduce resistance is to use antimicrobial agents only when necessary and to use the shortest effective course.¹ The timely selection and administration of appropriate antimicrobial therapy can significantly impact treatment outcomes, especially in patients with severe or life-threatening conditions.⁴ The recognised frequent misuse and overuse of antibiotics in hospitals and the impact on therapeutic efficacy, bacterial resistance and costs warrant the implementation of programmes that aim to improve the use of antibiotics in hospitals.⁵

Multiple studies have indicated that stewardship programmes aim to optimise individual patient outcomes whilst minimising unintended consequences, such as the generation of resistant

organisms and untoward effects in the individual patient.¹ These programmes typically involve evidence-based guidelines, educational programmes and regular feedback of antibiotic usage data to prescribers to promote rationale-based and evidence-based prescribing.¹

The pharmacist's role in combating and preventing infectious diseases is essential, as antibiotic regimens become more complex due to the continuous evolving epidemiology of infections. Pharmacist-directed antimicrobial stewardship programmes have proliferated considerably over the past decade.^{4,6} The Minister of Health of South Africa launched the National Antimicrobial Resistance Strategy Framework published in 2015, calling on all healthcare providers to use antimicrobials appropriately.² However, in South Africa there is little data on the content and effectiveness of the education of pharmacy students regarding antimicrobial stewardship. The purpose of this study was, therefore, to assess the knowledge and perceptions of fourth year pharmacy students in South Africa regarding antimicrobial stewardship concepts. The study further aimed to identify gaps in knowledge in order to provide appropriate recommendations for undergraduate pharmacy curricula that may lead to more appropriate use of antimicrobials in future practice.

Method

Study design and population

This was a quantitative descriptive survey. The target population for this study comprised all final (fourth) year pharmacy students registered at universities in South Africa. The universities offering

Table 1: Response rate by university

University	Number of final year pharmacy students	Response rate	
		Number (n)	Percentage (%)
A	241	14	5.8
B	160	29	18.1
C	75	22	29.3
D	126	23	18.3
E	103	11	10.7
F	144	33	22.9
G	69	69	100.0
H	60	59	98.3
Overall	978	260	26.6

the degree in pharmacy are the University of Western Cape (UWC), Sefako Makgatho Health Sciences University (SMU) in collaboration with Tshwane University of Technology (TUT), University of KwaZulu-Natal (UKZN), Rhodes University (RU), Nelson Mandela Metropolitan University (NMMU), North West University (NWU), University of Limpopo (UL) and the University of the Witwatersrand (Johannesburg) (WITS). Inclusion criteria for student participation in the survey were the following: enrolled for the BPharm degree at the university; in the final year of study; willing to participate in the survey; and provide written informed consent.

Data collection instrument and procedures

An electronic questionnaire with response options was used to evaluate fourth year pharmacy students' (i) background knowledge and perceptions on antimicrobial stewardship; (ii) perceptions and attitudes about antimicrobial prescribing and resistance; (iii) knowledge of the goals, objectives and development strategies of antimicrobial stewardship; and, (iv) the quantity and perceived quality of education on antimicrobial stewardship. The questionnaire was adopted from a similar study done by Abbo et al. in 2013.⁷ The questionnaire was pretested for readability, length and relevance of the questions amongst five pharmacist interns from the Pharmacy Department at SMU, who had completed their undergraduate education in the previous year.

Data were collected using the electronic platform Typeform™. The questionnaire was made available online at each university's departmental student portal for a period of 12 weeks, from June 2015 to August 2015. A reminder email was sent on a weekly basis to a dedicated member of staff at the pharmacy department of each university, as a strategy to increase the response rate.

Ethical considerations

Ethical approval was obtained from the Sefako Makgatho University Research Ethics Committee (SMUREC/H/149/2015:UG). Permission to conduct the survey was obtained from the Head of the Pharmacy School at each of the universities. Participation was voluntary and responses were anonymous.

Data analysis

Data were entered onto Microsoft Excel® spreadsheets and exported to IBM Statistical Analysis Software® (SAS) for analysis. Prior to analysis, universities were de-identified and recoded as "A", "B", "C", "D", "E", "F", "G" and "H". Frequencies and percentages were calculated for all variables. The Fisher exact test or the Chi-Square test was used to test for differences in responses between

the different universities. Statistical significance was set at $p \leq 0.05$.

Results

Response rate

Two hundred and sixty (26.6%) of the 978 fourth year pharmacy students at the eight universities offering the pharmacy degree in South Africa completed the survey. The overall response rate was 26.6%, ranging from 5.8% to 100.0%. Response rates by institution are shown in Table 1.

Student demographics

Overall, 66.2% of the respondents were female. Nearly two-thirds (65.0%) of the students were between the ages of 22 and 25 years, 15.8% were younger than 22 years and 19.2% were over the age of 25 years.

Background knowledge and perceptions on antimicrobial stewardship

Respondents' background knowledge and perceptions on antimicrobial stewardship is summarised in Table 2. Most of the students (83.5%) indicated that they know what antimicrobial stewardship is and that they were familiar with antimicrobial stewardship programmes in South Africa (71.9%), with significant differences between the universities ($p < 0.001$).

The vast majority (95.8%) of respondents indicated that implementation of antimicrobial stewardship programmes are essential in South Africa. Only 24.6% of respondents reported that prescribing and use of antimicrobials are actually appropriate in South Africa, with university responses ranging from 6.1% to 40.7% ($p < 0.001$). Most respondents agreed that antimicrobial stewardship involves the appropriate selection of antibiotics (95.0%), the appropriate dosing and selection of route of administration (86.5%), and the appropriate duration of therapy (88.8%), while only half of them (50.4%) indicated that the study of antibiotics is also a part of antimicrobial stewardship.

Perceptions and attitudes about antimicrobial prescribing and resistance

Respondents' perceptions and attitudes about antimicrobial prescribing and resistance are summarised in Table 3. The majority (97.7%) of respondents agreed that antimicrobial resistance is a worldwide problem. According to most of the respondents, the promotion of antimicrobial resistance is attributed to the widespread and overuse of antimicrobials (94.2%), poor patient adherence to medication (89.5%), and the

Table 2: Background knowledge and perceptions of final year pharmacy students on antimicrobial stewardship

Background knowledge and perceptions on antimicrobial stewardship	Percentage of students per university									p value
	All (n = 260)	A (n = 14)	B (n = 29)	C (n = 22)	D (n = 23)	E (n = 11)	F (n = 33)	G (n = 69)	H (n = 59)	
Know what antimicrobial stewardship is	83.5%	64.3%	51.7%	100.0%	91.3%	45.5%	63.6%	94.2%	100.0%	<0.001 ^a
Familiar with antimicrobial stewardship programmes in South Africa	71.9%	35.7%	41.4%	95.5%	69.6%	27.3%	36.4%	95.7%	88.1%	<0.001 ^b
Implementation of antimicrobial stewardship programmes are essential in South Africa	95.8%	92.9%	96.6%	100.0%	95.7%	72.7%	97.0%	95.7%	98.3%	0.073 ^a
Prescribing and use of antimicrobials are appropriate in South Africa	24.6%	14.3%	10.3%	9.1%	8.7%	9.1%	6.1%	40.6%	40.7%	<0.001 ^b
Antimicrobial stewardship involves the following:										
1. Appropriate selection of antimicrobials	95.0%	92.9%	82.8%	100.0%	100.0%	90.9%	93.9%	97.1%	96.6%	0.088 ^a
2. Appropriate dosing and route of administration	86.5%	78.6%	75.9%	95.5%	73.9%	90.9%	78.8%	92.8%	91.5%	0.045 ^a
3. Appropriate duration of antimicrobial therapy	88.8%	78.6%	75.9%	95.5%	73.9%	81.8%	93.9%	95.7%	89.8%	0.003 ^a
4. The study of antimicrobials	50.4%	28.6%	58.6%	27.3%	47.8%	45.5%	48.5%	60.9%	50.8%	0.122 ^b

^aFisher exact test.^bChi-Square test.

use of broad spectrum antibiotics when narrow spectrum is available (84.2%). Nearly half of the respondents (48.8%) perceived that the substandard quality of antimicrobials promotes resistance, with significant differences in the responses from the individual universities ($p = 0.007$). Only a third (33.8%) of all respondents perceived that poor handwashing practice was a contributing factor to antimicrobial resistance.

The majority of respondents (98.5%) indicated that better use of antimicrobials will reduce problems with resistance. In terms of interventions that can be used to combat antimicrobial resistance, responses from the universities in most cases differed significantly, except in the case of the development of institutional guidelines for antimicrobial use, as indicated by 86.2% of respondents. Overall, 92.3% of the respondents indicated education on antimicrobial therapy, whether for fellow healthcare workers or patients, would combat resistance; while, two-thirds (65.8%) of the respondents reported that a reduction in antimicrobial usage would combat resistance.

Most of the respondents (98.1%) agreed that inappropriate use of antimicrobials can harm patients. Nearly all of the respondents (98.5%) felt that a strong knowledge of antimicrobials is important in their careers. The students were asked to identify bacteria that are currently the most problematic with regards to resistance (Table 3), 12.3% reported the virus *Herpes simplex* and

13.5% reported the virus *Influenza A* as bacteria, with significant differences between the universities for the latter ($p = 0.006$). The vast majority of students indicated that they would like to have more education on the appropriate use of antimicrobials (96.5%) and on antimicrobial resistance (93.1%), with no significant differences amongst the universities for the last-mentioned.

Antimicrobial stewardship goals, objectives and development strategies

Final year pharmacy students' responses regarding the goals of antimicrobial stewardship, objectives and development strategies are summarised in Table 4. The majority of students agreed that the goals of antimicrobial stewardship seek to reduce antimicrobial resistance (98.5%). There was also agreement that additional goals were to reduce the hospital stay (72.7%), and minimise toxicity and other adverse effects (83.1%), although with significant differences in the responses from the different universities ($p < 0.001$).

Overall, 95.0% of respondents felt that clinical and hospital pharmacists should be part of the antimicrobial stewardship team, and 83.8% were of opinion that it is one of the responsibilities of the clinical pharmacist to assemble and lead the core antimicrobial stewardship team. Infectious disease physicians and infection-control staff should be included in the team, as reported by 91.9% and 81.5% respondents, respectively.

Table 3: Perceptions and attitudes of final year pharmacy students about antimicrobial prescribing and resistance

Perceptions and attitudes about antimicrobial prescribing and resistance	Percentage of students per university									p value
	All (n = 260)	A (n = 14)	B (n = 29)	C (n = 22)	D (n = 23)	E (n = 11)	F (n = 33)	G (n = 69)	H (n = 59)	
Antimicrobial resistance is a worldwide problem	97.7%	100.0%	93.1%	95.5%	100.0%	100.0%	93.9%	100.0%	98.3%	0.211 ^a
Antimicrobial resistance is promoted by:										
1. Widespread/overuse of antimicrobials	94.2%	85.7%	89.7%	100.0%	100.0%	90.9%	90.9%	94.2%	96.6%	0.298 ^a
2. Use of broad spectrum antimicrobials when narrow spectrum is available	84.2%	85.7%	79.3%	66.7%	73.9%	90.9%	66.7%	91.3%	88.1%	0.053 ^a
3. Poor hand washing practice	33.8%	21.4%	31.0%	54.5%	21.6%	18.2%	30.3%	33.3%	39.0%	0.334 ^b
4. Poor patient adherence to medication	89.5%	78.6%	82.8%	100.0%	87.0%	81.8%	90.9%	89.9%	93.2%	0.258 ^a
5. Substandard quality of antimicrobials	48.8%	35.7%	31.0%	40.9%	47.8%	63.6%	30.3%	66.7%	50.8%	0.007 ^b
Better use of antimicrobials will reduce problems with antimicrobial resistance	98.5%	92.9%	96.6%	100.0%	95.7%	100.0%	100.0%	98.6%	100.0%	0.271 ^a
Interventions that can possibly combat antimicrobial resistance:										
1. Antimicrobial usage policies	86.9%	64.3%	65.5%	90.9%	78.3%	63.6%	93.9%	92.8%	98.3%	<0.001 ^a
2. Reduction of antibiotic use	65.8%	85.7%	37.9%	77.3%	47.8%	81.8%	57.6%	78.3%	64.4%	0.001 ^b
3. Establish national antimicrobial resistance surveillance	79.6%	28.6%	55.2%	90.9%	87.0%	72.7%	75.8%	89.9%	88.1%	<0.001 ^a
4. Development of institutional guidelines for antimicrobial use	86.2%	78.6%	79.3%	90.9%	78.3%	100.0%	81.8%	92.8%	84.7%	0.257 ^a
5. Education on antimicrobial therapy	92.3%	64.3%	86.2%	95.5%	91.3%	90.9%	90.9%	97.1%	96.6%	0.009 ^a
Inappropriate use of antimicrobials can harm patients	98.1%	92.9%	100.0%	100.0%	95.7%	100.0%	100.0%	100.0%	94.9%	0.166 ^b
Strong knowledge of antimicrobials is important for future career	98.5%	100.0%	96.6%	100.0%	100.0%	100.0%	100.0%	97.1%	98.3%	0.975 ^a
Would like more education on appropriate use of antimicrobials	96.5%	85.7%	96.6%	95.5%	95.7%	90.9%	100.0%	100.0%	94.9%	0.028 ^b
Would like more education on antimicrobial resistance	93.1%	78.6%	100.0%	86.4%	91.3%	100.0%	90.9%	98.6%	89.8%	0.085 ^a
Most troublesome microorganism:										
1. <i>Enterococcus faecium</i>	45.0%	42.9%	34.5%	63.6%	43.5%	18.2%	21.2%	69.6%	33.9%	<0.001 ^b
2. <i>Herpes simplex</i>	12.3%	7.1%	20.7%	0.0%	17.4%	9.1%	18.2%	7.2%	15.3%	0.183 ^a
3. <i>Staphylococcus aureus</i>	81.9%	100.0%	69.0%	90.9%	87.0%	90.9%	87.9%	92.8%	61.0%	<0.001 ^a
4. <i>Klebsiella pneumoniae</i>	55.4%	64.3%	41.4%	63.6%	65.2%	63.6%	45.5%	65.2%	45.8%	0.148 ^b
5. <i>Influenza A</i>	13.5%	7.1%	20.7%	0.0%	13.0%	9.1%	27.3%	4.3%	20.3%	0.006 ^a
6. <i>Acinetobacter baumannii</i>	44.2%	50.0%	24.1%	31.8%	30.4%	9.1%	15.2%	92.8%	28.8%	<0.001 ^b
7. <i>Pseudomonas aeruginosa</i>	66.9%	78.6%	79.3%	72.7%	87.0%	72.7%	66.7%	50.7%	66.1%	0.028 ^b

^aFisher exact test.

^bChi-Square test.

The majority of respondents felt that promoting optimal use of antimicrobial agents (92.3%) and education of other health care professionals (91.5%) is part of the role of the pharmacist in antimicrobial stewardship. Very few of the students (7.3%; 19

respondents from five universities) reported that prescribing antimicrobial agents to patients over the counter is part of the role of the pharmacist.

Table 4: Final year pharmacy students' knowledge of antimicrobial stewardship goals, objectives and development strategies

Antimicrobial stewardship goals, objectives and development strategies	Percentage of students per university									p value
	All (n = 260)	A (n = 14)	B (n = 29)	C (n = 22)	D (n = 23)	E (n = 11)	F (n = 33)	G (n = 69)	H (n = 59)	
Goals of antimicrobial stewardship seek to achieve:										
1. Increasing antimicrobial use	6.2%	0.0%	3.4%	9.1%	0.0%	0.0%	9.1%	0.0%	16.9%	0.004 ^a
2. Reducing hospital stay	72.7%	28.6%	55.2%	86.4%	56.5%	72.7%	54.5%	81.2%	93.2%	<0.001 ^b
3. Increasing duration of therapy to ensure therapeutic efficacy	10.4%	0.0%	10.3%	0.0%	4.3%	9.1%	9.1%	11.6%	18.6%	0.265 ^a
4. Increasing use of broad spectrum antibiotics	7.7%	0.0%	3.4%	0.0%	4.3%	0.0%	12.1%	8.7%	13.6%	0.408 ^a
5. Reducing antimicrobial resistance	98.5%	100.0%	96.6%	100.0%	100.0%	100.0%	100.0%	100.0%	94.9%	0.391 ^a
6. Minimising toxicity and other adverse effects	83.1%	57.1%	72.4%	77.3%	69.6%	90.9%	72.7%	92.8%	94.9%	<0.001 ^a
Assembling and leading of the core team is one of the responsibilities of the clinical pharmacist	83.8%	85.7%	82.8%	90.9%	73.9%	90.9%	72.7%	81.2%	93.2%	0.167 ^a
Members of the antimicrobial stewardship team include:										
1. Infectious disease physicians	91.9%	92.9%	86.2%	95.5%	87.0%	90.9%	90.9%	95.7%	91.5%	0.711 ^a
2. Occupational therapists	20.8%	7.1%	13.8%	9.1%	26.1%	9.1%	9.1%	33.3%	23.7%	0.044 ^a
3. Clinical and hospital pharmacists	95.0%	92.9%	96.6%	100.0%	95.7%	90.9%	97.0%	94.2%	93.2%	0.904 ^a
4. Infection control staff	81.5%	64.3%	79.3%	77.3%	78.3%	63.6%	81.8%	87.0%	86.4%	0.298 ^a
5. Hospital cleaning staff	37.7%	35.7%	48.3%	18.2%	43.5%	9.1%	33.3%	49.3%	32.2%	0.050 ^b
The role of the pharmacist in antimicrobial stewardship:										
1. Promote optimal use of antimicrobial agents	92.3%	85.7%	96.6%	95.5%	87.0%	100.0%	90.9%	89.9%	94.9%	0.692 ^a
2. Prescribe antimicrobial agents over-the-counter	7.3%	14.3%	0.0%	0.0%	4.3%	9.1%	15.2%	0.0%	16.9%	<0.001 ^a
3. Educate health care professionals	91.5%	78.6%	89.7%	100.0%	78.3%	72.7%	93.9%	94.2%	96.6%	0.074 ^a
4. Work with therapeutic committees to develop policies	88.5%	78.6%	75.9%	90.9%	87.0%	90.9%	84.8%	97.1%	88.1%	0.055 ^a

^aFisher exact test.^bChi-Square test.

Education on antimicrobial stewardship

Perceptions of final year pharmacy students regarding the quantity and quality of education on antimicrobial stewardship at undergraduate level are summarised in Table 5. With reference to their pharmacy curricula, only 98 of the 260 respondents (37.7%) recalled having had formal training on antimicrobial stewardship, with significant differences in responses from the various universities ($p < 0.001$). The majority of respondents (90.0%) indicated that they would like more training on antimicrobial stewardship. There was a significant difference ($p < 0.001$) amongst the universities in terms of how respondents rated their knowledge on antimicrobial stewardship, with half of them (51.9%) rating it as average and 11.9% as poor.

Discussion

This study evaluated pharmacy students' knowledge and perceptions on antimicrobial stewardship and antimicrobial resistance. To the best of our knowledge, this study is the first to assess these aspects amongst pharmacy students in South Africa. The response rate for this study was relatively low, despite continued efforts over the 12 week study period to obtain a better response rate. This low response rate from the students at

the different universities is not unique to this particular study and similar trends have been observed in other settings.⁸

We found that although the majority of respondents were familiar with antimicrobial stewardship programmes in South Africa there were significant differences in the responses between the eight universities. Similar results were observed in a study conducted by Cotta and colleagues in 2014,⁹ in which 80.0% of the pharmacists had heard about antimicrobial stewardship. Only 24.6% of the respondents felt that prescribing and use of antimicrobials are appropriate in South Africa, with significant differences in the responses between the universities. These results concur with those reported by Abera in 2014,¹⁰ to the effect that one of the three leading causes of antimicrobial resistance is overuse and frequent prescribing of broad-spectrum antibiotics.

Results showed that the most important interventions to combat antimicrobial resistance are considered to be education on antimicrobial therapy, development of antimicrobial usage policies and the development of institutional guidelines for antimicrobial use. In this study, the majority of the respondents

Table 5: Perceptions of final year pharmacy students on the quantity and quality of education on antimicrobial stewardship

Quantity and quality of education on antimicrobial stewardship	Percentage of students per university									p value
	All (n = 260)	A (n = 14)	B (n = 29)	C (n = 22)	D (n = 23)	E (n = 11)	F (n = 33)	G (n = 69)	H (n = 59)	
Had formal training on antimicrobial stewardship	37.7%	28.6%	20.7%	54.5%	13.0%	27.3%	21.2%	39.1%	61.0%	<0.001 ^b
Hours of training received on antimicrobial stewardship:										
1. 1 – 4	27.7%	0.0%	3.4%	40.9%	13.0%	9.1%	6.1%	42.0%	47.5%	<0.001 ^b
2. 5 – 7	3.8%	7.1%	3.4%	9.1%	4.3%	0.0%	0.0%	2.9%	5.1%	<0.001 ^b
3. More than 8	6.2%	14.3%	0.0%	9.1%	17.4%	0.0%	3.0%	1.4%	10.2%	<0.001 ^b
4. No training	61.9%	78.6%	93.1%	40.9%	65.2%	90.9%	90.9%	53.6%	37.3%	<0.001 ^b
Would like more training on antimicrobial stewardship	90.0%	78.6%	96.6%	86.4%	82.6%	90.9%	97.0%	98.6%	79.7%	0.007 ^a
Rating of knowledge on antimicrobial stewardship:										
1. Poor	11.9%	28.6%	34.5%	0.0%	4.3%	9.1%	36.4%	0.0%	5.1%	<0.001 ^b
2. Average	51.9%	50.0%	48.3%	50.0%	69.6%	54.5%	51.5%	42.0%	59.3%	<0.001 ^b
3. Good	31.5%	14.3%	17.2%	27.3%	21.7%	36.4%	12.1%	53.6%	32.2%	<0.001 ^b
4. Very good	4.6%	7.1%	0.0%	22.7%	4.3%	0.0%	0.0%	4.3%	3.4%	<0.001 ^b

^aFisher exact test.
^bChi-Square test.

across the different universities shared the common perception that antimicrobial resistance is a worldwide problem, which is consistent with the findings of studies conducted elsewhere.^{9,10}

The three leading causes of antimicrobial resistance were widespread and overuse of antimicrobials, use of broad-spectrum antimicrobials when narrow spectrum is available and poor patient adherence to prescribed antimicrobials. This is consistent with studies conducted in Australia, Ethiopia, Scotland, France and Spain which reported that too many broad-spectrum antimicrobials, too many antimicrobial prescriptions, and inappropriate duration of therapy were leading causes of antimicrobial resistance.^{9,11,12}

Although most respondents were familiar with antimicrobial stewardship goals, objectives and development strategies, we found significant differences in the responses between the universities for certain aspects. When questioned on what they thought the role of the pharmacist is in antimicrobial stewardship, a few respondents reported prescribing of antimicrobials over the counter, with significant differences in the responses between the universities. However, in terms of legislation, according to the Good Pharmacy Practice rules of the South African Pharmacy Council, and the Medicines and Related Substances Act (Act 101 of 1965), a pharmacist is not allowed to sell Schedule 4 medication, which includes antimicrobials, over-the-counter without a prescription.^{13,14} Although some respondents felt that over-the-counter prescribing by a pharmacist is correct and one of the roles of the pharmacist, the majority of students felt promoting optimal use and education on the use of antibiotics are very important tasks a pharmacist can perform to aid in the prevention of antimicrobial resistance.

The study also identified significant differences in the responses between the universities with regards to education on antimicrobial stewardship. This was evident when respondents were asked to state the number of hours of training on antimicrobial stewardship received. Almost all of the respondents wanted more education on antimicrobial stewardship. Similar results were reported from a study on antimicrobial training, conducted amongst medical students at a medical school in the United States of America.¹⁵

Strengths of our study were that the survey was anonymous and voluntary, which likely reduced the tendency of the respondents to provide “socially desired” answers. The study was conducted in the final year of undergraduate study when students had completed their formal academic curriculum, thus providing a better estimate of their education almost upon graduation. A limitation to the study was the low response rates from most of the universities.

Conclusion

Our study has demonstrated that final year pharmacy students across all the universities share similar perceptions and attitudes in terms of antimicrobial stewardship. Differences in the extent of undergraduate training on this topic provided by the various pharmacy schools were evident. The results of this survey draw attention to this important educational gap, and efforts should be made to address these gaps during the undergraduate training of pharmacists. Our results, therefore, suggest that pharmacy students should be the target of teaching on antimicrobial usage, antimicrobial resistance and the principles of antimicrobial stewardship. However, it is important for all healthcare professionals to work together as a team to combat the increasing problem of resistance.

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