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Current knowledge and attitudes toward antibiotic use among community pharmacy personnel in a rural province in South Africa and the implications

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Background: Antimicrobial resistance (AMR) is an appreciable threat to public health, especially among low- and middle-income countries (LMICs), exacerbated by high levels of inappropriate prescribing and dispensing of antibiotics in these countries. There have been variable levels of dispensing of antibiotics without a prescription among community pharmacies in South Africa. Given the importance of community pharmacies, especially in rural South Africa, there is a need to assess their knowledge and attitudes towards antibiotics, AMR, and antibiotic stewardship. This was the aim of this study.

Methods: A previously piloted questionnaire was administered to pharmacy personnel currently operating community pharmacies in a rural province in South Africa, where dispensing of antibiotics without a prescription is likely to be greatest. The questionnaire included key knowledge questions regarding antibiotics and AMR, as well as ways to reduce AMR. Community pharmacies were divided into three categories: Independent, chain, and franchise pharmacies.

Results: A total of 128 pharmacies participated (75.7%), with independent pharmacies representing the majority (60.9%). A total of 313 completed questionnaires were returned (78.3% response rate), including responses from 106 pharmacists (33.9%) and 207 pharmacist assistants (66.1%). Overall, there was very good knowledge among both community pharmacists and pharmacist assistants concerning antibiotics and AMR. However, there was a significant misconception regarding the potential role of antibiotics in relieving pain. Encouragingly, attitudes regarding the risks associated with obtaining antibiotics without a prescription among both community pharmacists and

pharmacist assistants were high. There was also strong agreement among both community pharmacists and pharmacist assistants for potential solutions to AMR. **Conclusion:** Overall, the findings showed that most pharmacists and pharmacist assistants in this rural province demonstrated a strong understanding of the effectiveness of antibiotics in bacterial infections and their lack of effectiveness to treat viral infections. They also demonstrated considerable knowledge regarding the risks associated with the inappropriate dispensing of antibiotics without a prescription, as well as ways to address rising AMR rates.

KEYWORDS

community pharmacists, antibiotics, knowledge, attitudes, practices, antimicrobial resistance, antimicrobial stewardship, South Africa

1 Introduction

Antimicrobial resistance (AMR) is an increasing global threat in view of appreciable and growing morbidity, mortality, and costs, becoming the next pandemic unless multiple activities are urgently undertaken (1–7). The greatest burden of AMR is currently in low- and middle-income countries (LMICs), which include sub-Saharan African countries (8–11). AMR is driven by the misuse of antibiotics, including appreciable purchasing of antibiotics without a prescription for essentially self-limiting infections, which is particularly prevalent in LMICs, including sub-Saharan Africa (10, 12–20). Coupled with this are concerns regarding hygiene and sanitation, diagnostic facilities, and low vaccine uptake where effective vaccines are available (11, 21–24).

Ongoing global activities to reduce AMR include the World Health Organization Global Action Plan instigated in 2015 (GAP) (25–28), with the GAP subsequently translated into National Action Plans (29–32). South Africa has implemented its NAP (33), with key elements including the monitoring of antibiotic utilization patterns alongside a number of agreed activities to reduce AMR (34). This includes ongoing monitoring of the goals and objectives of the NAP combined with active surveillance of AMR patterns as well as instigating/monitoring antimicrobial stewardship (AMS) activities across sectors (35–41).

High rates of self-purchasing of antibiotics in sub-Saharan Africa are enhanced by the convenience and ready availability of antibiotics among community pharmacists and drug sellers, as well as lower costs when factoring in co-payments with seeing prescribers in primary healthcare (PHC) centers alongside associated travel costs and long waiting times, which are important considerations especially in rural areas (13, 16, 42–46). As a result, rates of purchasing antibiotics without a prescription have reached up to 100% in community pharmacies in some African countries (13, 47). Such activities are enhanced by concerns regarding the knowledge of community pharmacists and their assistants across Africa about antibiotics, AMR, and AMS (Table 1), coupled with pressure from patients for community pharmacists to dispense antibiotics for often self-limiting conditions (48–51).

There is a variable situation in South Africa regarding the purchasing of antibiotics without a prescription, as seen in the studies by Anstey Watkins et al. (2016) and Do et al. (2021) conducted in rural South Africa where there was very limited or no purchasing of antibiotics without a prescription (59, 60). However, Mokwele et al. (2022) did not find this, reporting that antibiotics were sold without a prescription primarily among privately-owned independent pharmacies (61). Sono et al. (2024) had similar findings to Mokwele et al. (2022) when surveying both community pharmacy personnel and patients in recent pilot studies (55, 61, 62) as well as in the main study, primarily among independent pharmacies in a rural province (63). Such activities occur despite South African legislation prohibiting the purchasing of antibiotics without a prescription in the country (13, 55).

We previously reported that community pharmacists and pharmacist assistants almost always or mostly (approximately 98%) offered symptomatic relief before dispensing antibiotics without a prescription to patients presenting with self-limiting infectious disease symptoms, including acute respiratory infections, with approximately half of them never suggesting antibiotics for self-limiting infectious diseases (63). Considering this, there is a need to further assess their knowledge and attitudes toward antibiotic use, as community pharmacists and pharmacist assistants play an increasingly important role in providing healthcare to patients within the South African healthcare system, as emphasized during the COVID-19 pandemic (49, 64–66). Community pharmacists have also begun to audit prescribers' prescriptions and provide feedback to prescribers to improve the future use of antibiotics, which can be built upon (67). This is essential given an appreciable increase in the utilization of antibiotics generally in the public healthcare system in South Africa in recent years, as well as specifically antibiotics from the WHO Watch list with their greater resistance potential (68–70). Watch antibiotics constituted 52% of total antibiotic use in the public sector in 2022, up from 21% previously (68), with rises in the

utilization of WHO Watch antibiotics also seen in other LMICs (70).

Consequently, the principal objective of this study was to determine the knowledge and attitudes of community pharmacists and pharmacist assistants regarding the use of antibiotics in this rural South African province. Subsequently, we assessed their agreement and support for potentially different policies to reduce AMR in South Africa. The results, combined with the findings we previously reported (63), can be used to suggest potential activities to reduce the inappropriate dispensing of antibiotics in South Africa and across Africa, building on recent suggestions among LMICs (18, 49, 50). This is particularly important in South Africa, given concerns regarding the rising utilization of Watch and Reserve antibiotics in the country, coupled with rising AMR rates, leading to renewed calls on the government to implement additional policies in line with the National Action Plan to reduce AMR (71).

2 Materials and methods

The methodology has been previously described in detail (63). Consequently, more limited details are provided in this paper.

2.1 Study setting, population, and study design

A rural province was selected for this study because the extent of purchasing antibiotics without a prescription in South Africa is likely to be greatest in this setting, given the appreciable differences seen in the extent of purchasing antibiotics without a prescription in previous studies (18, 55, 59–61). A descriptive survey methodology was used to collect data directly from community pharmacists and pharmacist assistants, with community pharmacies divided into three categories: chain, franchise, and independent pharmacies. Chain pharmacies include 'Clicks,' 'Dischem,' and 'Medirite' at Checkers (supermarket), which are owned by corporate entities. Franchise pharmacies are independently owned by franchisees. However, they operate under a brand name and include for instance 'The Local Choice,' 'Link,' and 'Van Heerden.' Independent pharmacies are standalone pharmacies that do not have any ties to a particular brand or group (63).

All community pharmacies in this province were targeted for this study, except for the 11 pharmacies included in the pilot study, as reported previously (55, 63).

Pharmacist assistants in South Africa work under the supervision of registered pharmacists to process prescriptions and deal with patients. They undergo a training program at selected Universities in South Africa, with the program consisting of two levels: basic and post-basic, with further on-the-job training (72). The courses are accredited by the South African Pharmacy Council (SAPC), with the basic Pharmacist Assistant Course (NQF Level 3) spanning 12 months (full-time) or up to 18 months (part-time). The content covers pharmaceutical principles, dispensing techniques, ethical practices, and inventory management. The duration of the Post Basic Pharmacist Assistant Course (NQF Level 4) typically spans an additional 12–18 months (part-time). This course delves deeper into pharmacology, patient care, chronic disease management, and clinical support. In addition, more advanced input into dispensing techniques is provided (73). Pharmacist assistants are principally certified. Pharmacists are university-trained with their degree accredited by the SAPC. They can either be employed as pharmacists or practice as the responsible pharmacist on the premises.

2.2 Data collection

Four trained data collectors, including TMM and MTM, collected the data. On the day of data collection, the pharmacist in charge of the pharmacy was approached with an invitation for all pharmacists and pharmacist assistants present in the pharmacy at that time to participate in the study. The rationale for the study was explained to those present, with a request to complete the questionnaire independently.

Each questionnaire was accompanied by a consent form that participants were requested to sign prior to completing the questionnaire. Participants were instructed to place the signed consent forms in a sealed box within the pharmacy. Pharmacists and pharmacist assistants were similarly requested to place their completed anonymized questionnaires in a provided sealed envelope, which was then placed in a separate sealed collection box in the pharmacy. Both sealed boxes were collected at the end of the day or the following day, depending on the logistical feasibility during data collection.

2.3 Data collection instrument

We previously described the development of the self-administered questionnaire (Supplementary Table 1) and reported the pilot study in detail (55). Briefly, the initial questionnaire was based on the published literature, coupled with the considerable knowledge of the co-authors in this area, to cover three principal domains (13, 74–76). The subsequent pilot study ensured that the revised final questionnaire was relevant, comprehensive, understandable, and appropriately structured (55). This was important for meeting the overall objectives of the study. The pilot study confirmed that the questionnaire for the main study could be completed within 10 minutes to enhance participation (55). For the knowledge and attitude domains of the questionnaire, which are reported in this study, key variables related to the knowledge of antibiotics and AMR, as well as attitudes towards the risks associated with antibiotic use. Potential solutions to help reduce AMR in the country were also included in the final questionnaire, with potential health authority activities based on previous publications combined with the considerable knowledge of the co-authors. We have used this approach before in previous studies (12, 13, 15, 29, 49).

TABLE 1 Examples of concerns with knowledge, attitude and practices regarding antibiotics and AMR among community pharmacy personnel across Africa.

Country	Author and year	Key findings
Ethiopia	Belachew et al., 2022 (52)	• Among 276 community drug outlet personnel completing a self-administered questionnaire, only 9% believed that keeping leftover antibiotics from a previous course is acceptable, only 19.5% believed that patients with coughs and colds should always be treated with antibiotics, and 19.6% that antibiotics should be stopped when symptoms resolve • However, 31.9% of participants believed antibiotics can treat viral diseases, 45.1% believed that UTIs can be treated with antibiotics irrespective of their cause, and 26.1% of participants believed that acute sore throats can be treated with antibiotics regardless of the cause
Ghana	Ngyedu et al., 2023 (44)	• There was a high prevalence of selling antibiotics without prescription to simulated patients—88.3% of occasions; greatest for pediatric diarrhea (95.3%) compared to URTIs (77.6%, with cough syrups offered on 10% of occasions) • Of concern was that azithromycin was the antibiotic typically offered to simulated patients (63 out of 64 occasions)—with metronidazole typically offered for pediatric diarrhea • Encouragingly, where patients were refused antibiotics, this involved a pharmacist
Kenya	Gacheri et al., 2024 (53)	• All 243 pharmacies contacted reported that they sold one or more antibiotics to patients suspected of having COVID-19—despite this being a viral infection, with 81.5% of participating pharmacies reporting that they prescribed an antibiotic without asking for a prescription • Azithromycin (99.1%), amoxicillin-clavulanic acid (77%), cefuroxime (64.9%) and amoxicillin (approx. 50%) were the four most commonly sold antibiotics to patients suspected of having COVID-19
Nigeria	Akpan et al., 2021 (54)	• 68% of pharmacists visited by simulated patients (75 in total) recommended an antibiotic for patients stating they had a common cold, with azithromycin (43%), co-amoxiclav (24%), and cotrimoxazole (20%) being the most frequently dispensed antibiotics • 72% of visited pharmacists also dispensed an antibiotic for patients presenting with acute diarrhea, with 15% dispensing more than one antibiotic. The most frequently dispensed antimicrobial for acute diarrhea was metronidazole, on 82% of occasions
Mozambique	Torres et al., 2020 (46)	• 88.2% of 17 surveyed pharmacists admitted to dispensing antibiotics without a prescription, with the most commonly dispensed antibiotics being amoxycillin, co-amoxiclav and cotrimoxazole • ARIs, including sore throats, fever, coughs, and influenza, alongside UTIs and vaginal discharge, were common conditions for which antibiotics were being purchased without a prescription
South Africa	Sono et al., 2024 (55)	• Only five of the 14 pharmacist assistants participating in a pilot study using a self-administered questionnaire agreed that antibiotics cannot treat influenza • In addition, they stated that antibiotics should not be prescribed as preventative measures for these self-limiting conditions • Two of the 14 assistants also stated that patients could stop taking antibiotics when their symptoms resolved, and three of the 14 did not know what AMR was
Tanzania	Horumpende et al., 2018 (56)	• A total of 82 pharmacies were visited using simulated clients, with 92.3% of retailers subsequently dispensing antibiotics without prescriptions, typically ampiclox for coughs and azithromycin for painful urination • Only 5.9% of retailers voluntarily gave instructions for medicine use, with no retailer voluntarily explaining possible drug side effects of antibiotics
	Ndaki et al., 2021 (57)	• Among 1,148 drug outlets (community pharmacies and accredited drug dispensing outlets), the dispensing of amoxicillin without a prescription was common (88.2% of pharmacies) to mystery clients asking for amoxicillin (and if asked for UTIs) • Of concern is that most outlets visited (98%—99% across three regions) were happy to sell a half course of amoxicillin on demand, typically without asking the client any questions • There were, however, significant variations among regions; in Mbeya and Kilimanjaro, accredited drug dispensing outlets were more likely to do this than pharmacies, but no difference was observed in Mwanza
Zambia	Mudenda et al., 2021 (58)	• Seventy-five percent of 144 participating community pharmacists demonstrated poor practices towards ABR and AMS • This included dispensing antibiotics for longer than required and only sometimes educating patients about antibiotics • Having said this, 99.3% of participants believed that community pharmacists must take responsibility for reducing ABR in Zambia

ABR, Antibiotic Resistance; AMS, Antimicrobial Stewardship; ARIs, Acute Respiratory Infections; URTIs, Upper Respiratory Tract Infections; UTIs, Urinary Tract Infections.

Table 2 shows the questions included in the knowledge and attitude domains with respective response options, i.e., 'True,' 'False,' or 'Do not know' for knowledge questions and a 5-point Likert scale ranging from 'Strongly agree' to 'Strongly disagree' for the attitude domains (77–80). The final questions, divided into three components, were deliberately direct to reduce the chances of ambiguity.

This combined approach, incorporating questionnaire development based on the published literature combined with input from key personnel knowledgeable in the subject area and

subsequently tested in a pilot study, is based on the approach used in multiple published studies in this subject area (46, 52, 53, 58, 80, 81).

2.4 Data management and analysis

Data entry was performed using Microsoft Excel™, with the initial entry completed by TMM. To ensure the reliability of data entry, a second individual verified the data accuracy by double-checking the entered data. Prior to analysis, the dataset was subjected to cleaning and coding procedures to standardize the format of variables, address missing values and correct any inconsistencies.

Following these procedures, the final dataset was imported into Jamovi (https://www.jamovi.org/) for statistical analysis. Descriptive statistics included frequencies and percentages for categorical variables and means with standard deviation (SD) for age. For the purpose of summarizing knowledge scores and undertaking statistical analyses, responses were categorized as 'good knowledge' and 'poor knowledge.' Attitude responses were combined and categorized into two categories: 'positive attitudes' (strongly agree; agree) and 'negative attitudes' (strongly disagree; disagree; neutral). The Fischers exact test was used to investigate differences in knowledge and attitudes between pharmacists and pharmacist assistants, with $p < 0.05$ considered as statistically significant.

2.5 Ethical considerations

Ethical approval for this study was obtained from the Sefako Makgatho University Research Ethics Committee. Since no data were collected from public health facilities, the National Department of Health was not approached for permission to collect data. Participation in the study was entirely voluntary, with potential participants being informed that they could withdraw at any time without providing a reason for their decision. Before participating in the study, each participant provided written informed consent. To ensure anonymity, signed consent forms were placed in a sealed box separate from the survey responses.

All collected information was treated as confidential, with data stored securely in a password-protected computer and backed up in a cloud service, accessible only to the principal investigator (TMM). Data will be kept securely for 5 years following the publication of the study results and will then be destroyed in accordance with university policies.

3 Results

3.1 Response rate and sample

As reported previously (63), 17 of the 186 pharmacies (9.1%) in this rural province were nonoperational at the time of data collection, leaving 169 operational pharmacies. Among the 169 operational pharmacies, 41 (24.3%) declined to participate for various reasons. The reasons included time constraints, the need for owner approval before participation, or the absence of qualified personnel to complete the questionnaire. This resulted in a 75.7% participation rate at the pharmacy level (128 of 169 operational pharmacies). These were principally independent pharmacies (60.9%, n = 78), with chain and franchise pharmacies accounting for 21.9% (n = 28) and 17.1% (n = 22), respectively, of all pharmacies surveyed.

Overall, 400 questionnaires were distributed among the participating pharmacies, of which 313 completed questionnaires were returned, yielding a 78.3% response rate at the individual questionnaire level. The participants included 106 pharmacists (33.9%) and 207 pharmacist assistants (66.1%). Pharmacist assistants were the sole participants in a minority of chain and franchise pharmacies; however, they were the sole pharmacy personnel present in 37.2% of independent pharmacies.

3.2 Sociodemographic information

The mean age of the participants in this study was 36.7 (SD: 7.9) years, with the mean age of pharmacist assistants [35.0; SD: 6.1)] being younger than pharmacists [39.9; SD: 9.7)]. There were equal numbers of male and female pharmacists participating in the study, with a higher number of female (127, 61.4%) than male pharmacist assistants (Table 3). Most participants had more than 10 years of experience, with pharmacist assistants typically having only a certificate (95.7%). All participants were registered with SAPC as either pharmacists, post-basic pharmacist assistants, or learner pharmacist assistants, with most employed on a full-time basis (88.2%).

3.3 Knowledge of antibiotics and AMR

This study assessed the knowledge of pharmacists and pharmacist assistants regarding antibiotics, their use, and their effectiveness. Overall, there was very good knowledge among both community pharmacists and pharmacist assistants concerning these subjects, with no statistically significant difference between the two groups (Table 4). Consequently, no further analyses, including those of potential predictors of misconceptions, were performed.

However, there was a misconception regarding the statement 'Antibiotics can relieve pain,' where only 3.2% of participating pharmacists and 3.2% of pharmacist assistants answered this correctly. This indicates a notable misunderstanding of this question, given the high level of correct answers for the other statements and all community pharmacists in the pilot study answering this correctly (55).

3.4 Attitudes toward the risks associated with obtaining antibiotics and potential solutions of antibiotic resistance

Overall, the attitudes of both community pharmacists and pharmacist assistants regarding the risks associated with

TABLE 2 Key knowledge and attitude questions included in the data collection instrument.

Domains	Questions	Response options
Knowledge: Antibiotics and AMR	Antibiotics are only effective for treating bacterial infections	True; False; Do not know
	Antibiotics are effective against the common cold or influenza	
	Antibiotic resistance only occurs when antibiotics are not taken as prescribed	
	The misuse of antibiotics contributes to the development of antimicrobial resistance.	
	Antibiotic resistance is a global health concern that affects all countries	
	Antibiotics can prevent future bacterial infections	
	Antibiotics can relieve pain	
	Patients can stop taking antibiotics when symptoms improve	
Attitudes: Risks associated with antibiotic use	I am aware of the risks associated with obtaining antibiotics without a prescription	Strongly agree; Agree; Neutral; Disagree; Strongly disagree
	I understand the importance of completing a full course of antibiotics	
	Educating patients about the appropriate use of antibiotics can help reduce antibiotic resistance	
	Many infections are becoming increasingly resistant to treatment with antibiotics	
	Antibiotic resistance can affect me or my family	
	Antibiotic resistance is a huge problem in the world	
	AMR poses a serious threat to global public health	
	AMR can be transmitted from person to person	
Attitudes: Potential solutions for AMR	Antibiotics must only be prescribed by an authorised healthcare worker	Strongly agree; Agree; Neutral; Disagree; Strongly disagree
	Doctors should only prescribe antibiotics when necessary	
	Everyone should take responsibility for using antibiotics responsibly	
	People should wash their hands regularly	
	Pharmacists are responsible for promoting the optimal use of antibiotics	
	Pharmacists are responsible for educating healthcare professionals, patients and the public	
	Pharmacists are responsible for preventing antibiotic misuse	
	Infection prevention is important in reducing AMR	

obtaining antibiotics without a prescription were positive, with no statistically significant differences between the two groups (Table 5). Similarly, there was a strong agreement, with no statistically significant differences identified, among community pharmacists and pharmacist assistants for potential solutions to AMR (Table 5). Consequently, no further analyses were performed.

4 Discussion and suggested activities

The study revealed that most participating pharmacists and pharmacist assistants demonstrated a strong understanding of the effectiveness of antibiotics against bacterial infections, coupled with their lack of effectiveness against self-limiting infections, such as colds and influenza (Table 5). This was an improvement from the pilot study, where only 5 of the 14 participating pharmacist assistants agreed that antibiotics cannot treat influenza and that antibiotics should not be prescribed as preventative measures (55); however, similar to the situation among pharmacists. In addition, 100% of the participating pharmacists and pharmacist assistants correctly stated that antibiotics cannot prevent future infections. This is unlike the situation in several African countries (Table 1). The improved knowledge among pharmacist assistants may reflect the outcome of discussions between participating pharmacists and assistants; however, further research is needed before we can make any conclusions with certainty.

Encouragingly, all the surveyed pharmacists and pharmacist assistants believed that antibiotics should not be stopped when patients feel better, which again was an improvement among

TABLE 3 Sociodemographic characteristics of participants stratified by profession.

Sociodemographic characteristic		Profession; n (%)		
		Pharmacist assistants (n = 207)	Pharmacists (n = 106)	Total (n = 313)
Sex	Male	80 (38.6)	53 (50.0)	133 (42.5)
	Female	127 (61.4)	53 (50.0)	180 (57.5)
Experience (years)	<1 yr	4 (1.9)	1 (0.9)	5 (1.6)
	1–5 yrs	73 (35.3)	10 (9.4)	83 (26.5)
	6–10 yrs	49 (23.7)	25 (23.6)	74 (23.6)
	>10 yrs	81 (39.1)	70 (66.0)	151 (48.2)
Qualification	Certificate	198 (95.7)	–	198 (63.3)
	Diploma	7 (3.4)	1 (0.9)	7 (2.7)
	Degree	1 (0.5)	105 (99.1)	106 (33.9)
	Grade 12	1 (0.5)	–	1 (0.3)
Registration with the South African Pharmacy Council	Pharmacist	–	65 (61.3)	65 (20.8)
	Responsible pharmacist	–	40 (37.7)	40 (12.8)
	Intern pharmacist	–	1 (0.9)	1 (0.3)
	Qualified post-basic assistant	193 (92.2)	–	193 (61.7)
	Learner basic/post-basic assistant	14 (7.8)	–	14 (4.4)
Employment	Full day	183 (88.4)	93 (87.7)	276 (88.2)
	Locum	24 (11.6)	11 (10.4)	35 (11.2)
	Owner	–	2 (1.9)	2 (0.6)

pharmacist assistants from the pilot (55). This is welcomed since patients in several African countries where affordability is a key issue have stated in several studies that they stop taking antibiotics when they feel better and are happy to share antibiotics with friends and family members to save money (49, 50). This suggests a strong foundation for responsible antibiotic use among pharmacy professionals in this rural province in South Africa, although further research is needed to confirm this. Our findings may also help explain why in the first study of Maluleke et al. (2025) community pharmacists and pharmacist assistants almost always or mostly offered (approximately 98%) symptomatic relief before dispensing antibiotics without a prescription to patients presenting with self-limiting infectious disease symptoms, including acute respiratory infections (63). In addition, approximately half never suggested antibiotics for self-limiting infectious diseases.

However, there was concern that only 9.4% of participating pharmacists and 7.2% of pharmacist assistants correctly answered the question relating to antibiotics being indicated to relieve pain. This may have been a misunderstanding, with participants thinking about infections that cause pain, such as tooth infections, with pain alleviated by antibiotics. However, this needs further research before we can say anything with certainty, especially as all seven community pharmacists in the pilot study answered this question correctly (55).

Encouragingly, both pharmacists and pharmacist assistants had considerable knowledge of the risks associated with obtaining antibiotics without a prescription. This is welcomed and suggests that pharmacy professionals surveyed acknowledge the increasing threat of AMR and the necessity of proactive interventions, including not dispensing antibiotics inappropriately without a prescription, to reduce AMR. Despite this knowledge, this practice still occurred, albeit to a limited extent, among nearly all participating independent pharmacies in this rural province (63). We have seen these differences between knowledge and practice among LMICs (49), which need to be addressed in the future. This includes investigating patients directly as they exit community pharmacies in rural provinces. This is because community pharmacy personnel may underestimate the extent of self-purchasing without a prescription, especially if such activities are illegal (82).

It was reassuring to see that pharmacists and pharmacist assistants recognized their responsibility in promoting the optimal use of antibiotics to members of the public presenting with infectious diseases. This builds on their appreciable knowledge in this area as

TABLE 4 Knowledge of antibiotics and AMR among pharmacy personnel stratified by profession.

Knowledge of antibiotics and AMR	Profession	N	Number (%) (N = 313)		P-value (95% CI)
			Good knowledge	Poor knowledge	
Antibiotics are only effective for treating bacterial infections	Pharmacist assistant	207	207 (66.1)	–	NA
	Pharmacist	106	106 (33.9)	–	
Antibiotics are effective against the common cold or influenza	Pharmacist assistant	207	196 62.6)	11 (3.5)	0.066 (0.004; 1.201)*
	Pharmacist	106	105 (33.5)	1 (0.3)	
Antibiotic resistance only occurs when antibiotics are not taken as prescribed	Pharmacist assistant	207	207 (66.1)	–	NA
	Pharmacist	106	106 (33.9)	–	
The misuse of antibiotics contributes to the development of antimicrobial resistance.	Pharmacist assistant	207	207 (66.1)	–	NA
	Pharmacist	106	106 (33.9)	–	
Antibiotic resistance is a global health concern that affects all countries	Pharmacist assistant	207	207 (66.1)	–	NA
	Pharmacist	106	106 (33.9)	–	
Antibiotics can prevent future bacterial infections # OR **	Pharmacist assistant	207	207 (66.1)	–	NA
	Pharmacist	106	106 (33.9)	–	
Antibiotics can relieve pain # OR **	Pharmacist assistant	207	15 (4.8)	192 (61.3)	0.514 (0.302; 1.943)*
	Pharmacist	106	10 (3.2)	96 (30.7)	
Patients can stop taking antibiotics when symptoms improve # OR **	Pharmacist assistant	207	207 (66.1)	–	NA
	Pharmacist	106	106 (33.9)	–	

*Fisher-Exact test; # OR ** Indicating 'False' constituted good knowledge.

TABLE 5 Attitudes toward the risks associated with antibiotic use and potential solutions for AMR among pharmacy personnel stratified by profession.

Risks associated with antibiotic use	Profession	N	Number (%) (N = 313)		P-value* (95% CI)
			Negative attitudes	Positive attitudes	
I am aware of the risks associated with obtaining antibiotics without a prescription	Pharmacist assistant	207	4 (1.3)	203 (64.9)	0.666 (0.201; 102.847)
	Pharmacist	106	1 (0.3)	105 (33.5)	
I understand the importance of completing a full course of antibiotics	Pharmacist assistant	207	4 (1.3)	203 64.9)	0.304 (0.339; −1.000)
	Pharmacist	106	–	106 (33.9	
Educating patients about the appropriate use of antibiotics can help reduce antibiotic resistance	Pharmacist assistant	207	–	207 (66.1)	NA
	Pharmacist	106	–	106 (33.9)	
Many infections are becoming increasingly resistant to treatment with antibiotics	Pharmacist assistant	207	1 (0.3)	206 (65.8)	1 (0.013; −1.000)
	Pharmacist	106	–	106 (33.9)	
Antibiotic resistance can affect me or my family	Pharmacist assistant	207	–	207 (66.1)	NA
	Pharmacist	106	–	106 (33.9)	
Antibiotic resistance is a huge problem in the world	Pharmacist assistant	207	–	207 (66.1)	NA
	Pharmacist	106	–	106 (33.9)	
AMR poses a serious threat to global public health	Pharmacist assistant	207	3 (1.4)	204 (98.6)	1 (0.086; 9.296)
	Pharmacist	106	2 (1.9)	104 (98.1)	

(Continued)

TABLE 5 Continued

Risks associated with antibiotic use	Profession	N	Number (%) (N = 313)		P-value* (95% CI)
			Negative attitudes	Positive attitudes	
AMR can be transmitted from person to person	Pharmacist assistant	207	13 (4.2)	194 (62.0)	0.489 (0.503; 3.639)
	Pharmacist	106	9 (2.9)	97 (31.0)	
Potential solutions for AMR					
Antibiotics must only be prescribed by an authorised healthcare worker	Pharmacist assistant	207	–	207 (66.1)	NA
	Pharmacist	106	–	106 (33.9)	
Doctors should only prescribe antibiotics when necessary	Pharmacist assistant	207	–	207 (66.1)	NA
	Pharmacist	106	–	106 (33.9)	
Everyone should take responsibility for using antibiotics responsibly	Pharmacist assistant	207	–	207 (66.1)	NA
	Pharmacist	106	–	106 (33.9)	
People should wash their hands regularly	Pharmacist assistant	207	–	207 (66.1)	NA
	Pharmacist	106	–	106 (33.9)	
Pharmacists are responsible for promoting the optimal use of antibiotics	Pharmacist assistant	207	2 (0.6)	205 (65.5)	0.551 (0.096; −1.000)
	Pharmacist	106	–	106 (33.9)	
Pharmacists are responsible for educating healthcare professionals, patients and the public	Pharmacist assistant	207	–	207 (66.1)	NA
	Pharmacist	106	–	106 (33.9)	
Pharmacists are responsible for preventing antibiotic misuse	Pharmacist assistant	207	8 (2.6)	199 (63.6)	0.768 (0.228; 3.241)
	Pharmacist	106	5 (1.6)	101 (32.3)	
Infection prevention is important in reducing AMR	Pharmacist assistant	207	–	207 (66.1)	NA
	Pharmacist	106	–	106 (33.9)	

*Fisher-Exact test

evidenced by their correct responses. This is to be welcomed, with pharmacists and their assistants recognized as key personnel in healthcare delivery, who are often the first HCPs that patients visit in LMICs with their infectious diseases, as well as other conditions, especially with viral infections such as coughs, colds, and influenza (12, 49, 83–87).

Several activities are suggested to improve future antibiotic use among community pharmacists and pharmacist assistants in this rural province (Box 1), with applicability throughout South Africa and beyond. This is in addition to implementing ASPs to further improve antibiotic use, building on experiences in other countries (Table 6).

We acknowledge several limitations of this study. Firstly, not all community pharmacists and their assistants in this rural province of South Africa participated in the study. However, 75.7% of the community pharmacies approached participated, adding to the robustness of the findings. Secondly, we where unable to verify the accuracy of the replies from the pharmacists or pharmacist assistants for their accuracy. This is an issue given some differences observed between the pilot and main study, including knowledge-related responses and answers to the question regarding antibiotics and pain relief. However, this limitation is common in self-administered questionnaires. In addition, we did not question pharmacists or their assistants directly, which may itself have introduced bias. Despite these limitations, we are confident in the findings and their implications for improving antibiotic utilization in this rural province and throughout South Africa.

5 Conclusion

We believe this study provides valuable insights into the knowledge and perceptions of community pharmacists and pharmacist assistants regarding antibiotics, AMR, and AMS in a rural province of South Africa. Overall, the findings showed that most pharmacists and pharmacist assistants in this rural province demonstrated a strong understanding of the effectiveness of antibiotics in treating bacterial infections and their lack of

BOX 1 Suggested activities to improve antibiotic use among community pharmacists and pharmacist assistants.

- Targeted education and training:
  - o Develop workshops and training sessions for community pharmacists and pharmacist assistants that specifically address potential misconceptions about antibiotics, including their role in pain relief and viral infections. This is particularly important to help them manage inappropriate requests from patients or carers for antibiotics to treat self-limiting conditions such as coughs, colds, and influenza, as well as misconceptions that antibiotics can provide pain relief, which is clearly not the case (49, 50). This approach has worked well in other countries (Table 6).
  - o Implement structured continuing education programs on antimicrobial stewardship to ensure that pharmacists and pharmacist assistants fully understand their responsibilities in improving the future use of antibiotics in South Africa, given current concerns. This includes the WHO AWaRe system and related guidance given concerns with the appreciable availability and dispensing of antibiotics from the WHO Watch list seen among community pharmacies across LMICs (49, 88–91), with increasing use of antibiotics from the WHO Watch list in the public healthcare system in South Africa in recent years (68).
  - o Trained community pharmacists can also support audits of prescribers to improve their antibiotic use, building on ongoing examples in South Africa (92).
- Public awareness campaigns:
  - o Support patient education programs in community pharmacies that focus on the importance of completing antibiotic courses and avoiding inappropriate self-medication (48, 49).
  - o Distribute informative materials in pharmacies and healthcare settings on AMR prevention strategies to promote appropriate antibiotic use among patients.
- Policy and regulatory srengthening:
  - o Advocate for stricter regulations on antibiotic dispensing, to enhance compliance with prescribing requirements. This can include more frequent inspections and potentially fines for pharmacy personnel, including responsible pharmacists and pharmacy owners, for selling antibiotics without a prescription (Table 6). However, if fines for community pharmacy personnel are too low, they may have limited impact as seen in Vietnam (93). Conversely, if fines are excessive, they may lead to the closure of community pharmacies and greater reliance on the informal sector, which is not ideal due to increased inappropriate dispensing of antibiotics, including substandard and falsified antibiotics (50, 94). Any potential fines though must be balanced against concerns with current excessive prescribing of antibiotics in primary care across South Africa including for self-limiting infections such as URTIs (Supplementary Table 2). This practice was not seen among community pharmacists and pharmacist assistants (63). Alongside this, instigating the Medicines and Related Substances Act Section 22A(15) in recent years has seen the scope of pharmacists activities increasing with pharmacists' prescribing via Primary Care Drug Therapy (PCDT) expanded for specific primary care conditions, including infectious syndromes governed by the Primary Health Care Standard Treatment Guidelines (95). The next step includes a regulatory pilot for pharmacist-initiated dispensing of selected antibiotics such as single-dose fosfomycin for uncomplicated urinary tract infections in women. This mirrors the structured, evidence-based protocols operationalized in the UK's Pharmacy First service. Current informal sales of antibiotics when requested without a prescription whilst illegal in South Africa reflect consumer needs alongside health system barriers. Consequently, a formalized, pharmacist-led access route with stewardship controls provides a pragmatic, safer alternative that also aligns with equity and national health priorities. These prescribing models must though entail explicit protocols, patient eligibility checklists, and robust post-dispensing surveillance, to ensure their safe use and minimise AMR risk.
  - o In countries such as the United Kingdom, pharmacists can dispense antibiotics for agreed infections, serving as an exemplar for the authorities in South Africa (13) especially given concerns with current excessive prescribing of antibiotics among prescribers in primary healthcare clinics in South Africa including for self-limiting infections such as URTIs (Supplementary Table 2).
- Enhance monitoring systems/IT infrastructure
  - o Seek to introduce IT systems to track antibiotics through the supply chain and reduce inappropriate antibiotic sales across all community pharmacies, particularly in rural areas. Such practices will also help limit the circulation of counterfeit antibiotics, which is a concern across Africa, although less so in South Africa (50, 94).
  - o Introducing IT systems will also support real-time monitoring of antibiotic use, allowing for the implementation of agreed quality indicators based on the WHO AWaRe classification to improve future use (96).
- Collaborative stewardship Initiatives:
  - o Strengthen interprofessional collaboration among pharmacists, other healthcare professionals, and government public health officials to ensure responsible antibiotic prescribing.
  - o Encourage pharmacies to engage in community outreach programs that reinforce responsible antibiotic use and infection prevention. South Africa can draw on global experiences including England's Pharmacy First and successes from pharmacists involved in stewardship initiatives (Table 6) to inform the creation of a legal pathway for pharmacists prescribing and dispensing specified antibiotics for defined indications, e.g. fosfomycin for acute uncomplicated cystitis representing a high-impact, low-risk pilot situation given current concerns with high levels of inappropriate prescribing of antibiotics in primary care (Supplementary Table 2).

NB: AMR = Antimicrobial resistance; AWaRe: Access, Watch and Reserve; LMICs = Low- and Middle-Income Countries; URTIs = Upper Respiratory Tract Infections.

TABLE 6 Antimicrobial Stewardship Programmes among community pharmacies and drug stores across LMICs including the effectiveness of educational campaigns.

Country	Author and year	Key findings
Bangladesh	Chowdhury et al. (2018) (97)	• A study was undertaken to assess the effectiveness of a one-day educational course, coupled with role-play and guidelines for acute respiratory infections (ARIs), in which antibiotics were recommended only for complicated cases. • Mixed results were seen in the subsequent follow-up of the behavior of drug sellers in pharmacies: o In children, a decrease in the dispensing of antibiotics for uncomplicated ARIs — 30% baseline down to 21% post-intervention ($p = 0.04$). Drug sellers though did dispense antibiotics for complicated ARIs resulting in referrals to physicians for complicated ARIs decreasing — 70% baseline vs. 58% post-intervention ($p = 0.03$) o Among adults, the dispensing of antibiotics without a prescription with uncomplicated ARI remained similar—48% baseline vs. 40% post-intervention ($p = 0.1$). However, increased for patients with complicated ARI — 44% baseline vs. 78% post-intervention ($p < 0.001$)

(Continued)

TABLE 6 Continued

Country	Author and year	Key findings
China	Chang et al. (2019) (13, 98)	• Multiple initiatives had been introduced in Shaanxi Province in China in recent years to reduce the purchasing of antibiotics without a prescription given rising concerns. These initiatives included (i) Stricter regulations for dispensing antibiotics; (ii) Stipulating there must be a qualified pharmacist's present to dispense antibiotics; (iii) increased frequency of unannounced pharmacy inspections and punishments for abuse; and (iv) improvements in pharmacists' education. • These multiple measures resulted: o Decreased antibiotic sales between 2011 and 201 o Decreased dispensing of antibiotics without a prescription for a 5-year-old child with diarrhea (simulated patient) during the same period — from 72.3% to 50.2% ($p < 0.0001$) o Similarly for simulated patients with upper respiratory tract infections—down from 95.8% to 69.5% ($p < 0.0001$).
Egypt	Kandeel et al. (2019) (99)	• A study was undertaken to assess the effectiveness of educational courses/campaigns among 596 participating pharmacists to raise their awareness regarding antibiotic prescribing for patients with acute respiratory infections. • The mean knowledge score regarding the judicious use of antibiotics improved from 3.3 ± 0.9 to 4.0 ± 1.2, with attitude scores regarding reducing antibiotic prescribing for colds, limiting their use to preserve their effectiveness and not dispensing antibiotics colds also improved — the % stating they never dispensed antibiotics (even sometimes) decreased from 58.4% to 25.2% among participating pharmacists. • Attitudes related to not overusing antibiotics to prevent resistant bacteria also improved among participating pharmacists.
Kenya	Various including Mukokinya et al. (2018), Muloi et al. (2019), Opanga et al. (2021), and Kimathi et al. (2022) (13, 100–103)	There have been mixed findings: • There were low levels of dispensing of antibiotics without a prescription (94.1% of antibiotics dispensed with a valid prescription) in the study of Mukokinya et al. (2018) among community pharmacies who were part of the training programme at the University of Nairobi (UoN). These contrasted with pharmacies not allied to UoN where 52% of surveyed pharmacists had sold antibiotics without a prescription. • At the start of the COVID-19 pandemic, Opanga et al. (2021) found no purchasing of antimicrobials without a prescription among patients with actual or suspected COVID-19 among community pharmacies allied to the UoN — typically alternative treatments including symptomatic treatments were recommended. • This compares with Kimathi et al. (2022) who found 23.4% of respondents had self-medicated with antibiotics during the pandemic, 60.6% at the onset of COVID-19 symptoms before confirmatory tests, with 51.5% self-medicating more than once.
Republic of Srpska	Various including Marković-Peković et al. (2017) and Bojanić et al. (2018) (13, 83, 104)	• Multiple programs including education of pharmacists regarding appropriate management of diseases including acute respiratory infections — coupled with guidelines for 42 of the most frequent diseases and conditions typically seen and stressing the importance of adequate communication and skills. Alongside this, greater enforcement of the regulations of guidelines banning the dispensing of antibiotics without a prescription plus potential fines for violation for Pharmacy Directors and personnel (Euro500–1,500 for pharmacy directors and Euro500–750 for pharmacy technicians). • The dispensing of antibiotics without a prescription decreased from 58% to 18.5% of pharmacies, with OTC therapy to alleviate symptoms was offered in 72.3% of pharmacies—up from 67.2%. OTC medication dispensed included throat and nasal sprays, decongestants, oral expectorants, and antihistamines. • Encouragingly, the most common reason for not dispensing of antibiotics to simulated patients was that antibiotics cannot be dispensed without a prescription.
Thailand	Arparsrithongsagul et al. (2015) (105)	• The intervention included principally education among grocery store personnel in a rural province in Thailand. Trained community leaders were used to try and reduce the extent of antibiotic availability in these grocery stores and their subsequent abuse. • In the active group — there were 87% fewer antibiotics available post-intervention compared with pre-intervention. • However, among grocery stores in the control group — there was only an 8% reduction in the availability of antibiotics between the two time periods.
Uganda	Bagonza et al. (2021) (106)	• An antimicrobial stewardship programme was undertaken to assess the effectiveness of peer-supervision among drug sellers (keeping registers) regarding the appropriate treatment of pneumonia and non-bloody diarrhea among children under 5 years of age. • A month after the introduction of peer supervision, the proportion of children appropriately treated for pneumonia symptoms increased by 10.84% in the intervention group. • Alongside this, the proportion of appropriately treated children with non-bloody diarrhea was 4% higher in the intervention group.

effectiveness in treating viral infections. The participating pharmacists and pharmacist assistants also demonstrated considerable knowledge of the risks associated with inappropriate dispensing of antibiotics without a prescription, as well as strategies to address rising AMR rates. However, some of the replies raised concerns. The next stages of the research will include assessing the situation among patients, including their experience with purchasing antibiotics without a prescription, as well as their knowledge and attitudes toward antibiotics, AMR, and AMS. The combined findings can be used to develop pertinent future polices for all key stakeholder groups in South Africa and across Africa to improve antibiotic dispensing and reduce AMR.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Sefako Makgatho University Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

TM: Investigation, Data curation, Methodology, Writing – review & editing, Conceptualization, Validation, Formal analysis, Visualization, Writing – original draft. MM: Writing – review & editing, Validation, Investigation, Formal analysis, Methodology, Data curation. AG: Conceptualization, Validation, Methodology, Data curation, Writing – review & editing. SC: Data curation, Validation, Methodology, Conceptualization, Investigation, Formal analysis, Writing – review & editing. VM-P: Methodology, Writing – review & editing, Validation, Formal analysis, Conceptualization, Data curation. NS: Data curation, Investigation, Conceptualization, Methodology, Writing – review & editing, Formal analysis. NR: Validation, Data curation, Methodology, Writing – review & editing, Conceptualization. BG: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Validation, Writing - original draft, Writing – review & editing. JM: Methodology, Formal analysis, Visualization, Investigation, Data curation, Supervision, Validation, Writing – review & editing, Conceptualization.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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