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Patient knowledge, attitudes and behaviors related to antimicrobial use in South African primary healthcare settings: development and testing of the CAMUS and its implications

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Background: Antimicrobial resistance (AMR) poses a global health threat, particularly in low- and middle-income countries (LMICs) including South Africa where limited resources and knowledge gaps exacerbate inappropriate antimicrobial use. To address this, the community antimicrobial use scale (CAMUS) was developed to assess patients' knowledge, attitudes and behaviors regarding antimicrobial use in South African primary healthcare (PHC) settings, with the aim of informing antimicrobial stewardship (AMS) strategies.

Methods: Development of the CAMUS was informed by a scoping review and theoretical constructs from the Health Belief Model, Social Cognitive Theory, and Theory of Planned Behavior. A pilot study was subsequently conducted in two South African districts, an urban and a rural district, with 30 adult participants to provide insights into patients' understanding of the items. Data collection involved administering CAMUS alongside a health literacy test followed by cognitive interviews to refine clarity and ensure understanding. A feasibility assessment was also conducted to evaluate the practical use of CAMUS in PHC settings.

Results: Participants demonstrated varied knowledge of antimicrobial use. While 60% correctly identified antibiotics as effective for bacterial infections, 93.33% incorrectly believed antibiotics could treat viral illnesses such as colds. Marginal health literacy was prevalent (86.67%). The CAMUS demonstrated feasibility, with an average completion time of 10 minutes. Questions were iteratively revised to improve future clarity and relevance based on the results of the cognitive interviews. Key findings highlighted misconceptions about antibiotics and the influence of social norms and systemic barriers on antimicrobial use behaviors.

Conclusion: The CAMUS effectively captures the knowledge, attitudes and behaviors of antimicrobial use in South African PHC settings. Pilot testing demonstrated its feasibility to use it as a tool to assess patient knowledge, attitudes and behaviors related to antimicrobial use in a larger population, to subsequently guide AMS initiatives by addressing knowledge gaps and related barriers to improve future antimicrobial use. Future research will include development of a shorter version of the CAMUS, followed by validation in larger, more diverse populations and in local languages to enhance its usability when investigating antimicrobial use and AMR across LMICs.

KEYWORDS

antimicrobial resistance, antimicrobial stewardship, primary healthcare, patient knowledge, attitudes, behaviors, South Africa

1 Introduction

Antimicrobial resistance (AMR) poses a global threat, undermining the effectiveness of treatments for bacterial infections and placing immense pressure on healthcare systems worldwide (1). AMR contributes to millions of deaths annually, with its impact particularly severe in sub-Saharan Africa, where infectious disease burdens and limited healthcare resources exacerbate the problem (2–7). Misuse and overuse of antimicrobials, including non-prescription access and self-medication with leftover antibiotics from friends and family members, are significant drivers of AMR in low- and middle-income countries (LMICs) including South Africa (1, 8–10).

South Africa has a two-tiered health system with a public sector serving most of the population and a private sector for those with private health insurance or the ability to pay for healthcare. Primary healthcare (PHC) facilities are the first point of contact for most patients and provide essential services such as diagnosis, treatment, and health promotion (10, 11). Given the high burden of infectious diseases and AMR, PHC facilities should play a key role in antimicrobial stewardship (AMS) and patient education (12).

In South Africa, inappropriate antimicrobial use is particularly problematic in PHC settings, where economic constraints, self-purchasing of antibiotics without a prescription, and critical knowledge gaps among patients contribute to widespread misuse (10, 12–14). A pilot study by Sono et al. (9) found that 60% of patients who obtained antibiotics in independent pharmacies (privately owned and operated pharmacies that function separately from large retail chains) did so without a prescription, often driven by convenience and the inability to afford medical consultations. These practices, coupled with patient misconceptions including believing antibiotics are effective against viral infections, highlight a need for targeted education and intervention strategies in South Africa to improve future antibiotic use (9, 10, 15–18). Similar issues are seen in other LMICs, where patient expectations for antibiotics, even for self-limiting conditions, influence inappropriate prescribing patterns by healthcare providers (19–24).

Efforts to combat AMR including South Africa's Antimicrobial Resistance Strategy Framework, emphasize antimicrobial stewardship (AMS) through regulatory measures, public education, and healthcare interventions (25, 26). However, AMS programs face significant challenges in PHC settings across LMICs, including inadequate diagnostic capabilities, resource constraints, and limited public awareness; although, this is beginning to change across Africa (27–30). A critical gap in these initiatives is the lack of robust tools to assess patients' knowledge, attitudes, and practices (KAP) regarding antimicrobial use, which has been found to be a prominent theme regarding antimicrobial use among community members in PHC settings (23).

Existing scales have provided valuable insights into antibiotic use behaviors; however, they do exhibit significant limitations when applied to LMICs. For instance, Byrne et al. (31) developed a questionnaire based on the Theory of Planned Behavior (TpB) to assess social and behavioral predictors of antibiotic misuse, identifying perceived behavioral control and social norms as key factors. However, this tool's sample size, weak internal consistency for some constructs, and exclusive testing in Australia limit its applicability to diverse socio-economic contexts including among African countries. Hill and Watkins (32) introduced the Appropriate Antibiotic Use Self-Efficacy Scale (AAUSES), which measures confidence in avoiding inappropriate antibiotic use.

While valid and internally consistent, the tool relies on data from Amazon Mechanical Turk participants, raising concerns about its generalizability as well as its lack of inclusion of healthcare providers' perspectives.

Community-based surveys, including those in Zambia and China (33, 34), and studies in South-East Asia (35–37) underscore the importance of capturing local behaviors and access patterns. However, these tools often rely on cross-sectional designs, small sample sizes, and self-reported data, which introduce bias and limit their ability to monitor behavioral change over time.

To address these gaps, the community antimicrobial use scale (CAMUS) was developed to assess antimicrobial use behaviors in South Africa's PHC settings. Grounded in established behavioral theories, including the Health Belief Model (HBM), Social Cognitive Theory (SCT), and the TpB, the CAMUS captures the complex cognitive, social, and systemic drivers of antimicrobial use. By incorporating context-specific indicators and behavioral insights, the CAMUS aims to provide actionable data to inform AMS interventions. It also seeks to address gaps in existing scales by ensuring cultural and contextual relevance, robust theoretical grounding, and practical feasibility for use in South African communities.

As a result, CAMUS builds on existing antimicrobial use assessment tools by integrating multiple theoretical perspectives to provide a more comprehensive measure of the cognitive, social, and structural influences on antimicrobial use. Unlike previous scales, which often emphasize knowledge or awareness, CAMUS encompasses attitudes, perceived risks and benefits, social norms, and healthcare system barriers that shape antimicrobial-seeking behavior. By incorporating constructs from HBM, SCT, and TpB, CAMUS ensures a more holistic assessment. Consequently, capturing individual perceptions of antimicrobial necessity and risk (HBM), the role of social influence and self-efficacy (SCT), and how perceived behavioral control and norms impact decision-making (TpB). This multidimensional approach ensures that CAMUS is not only theoretically robust but also practically useful to inform the design of targeted AMS interventions or to use as a tool to measure the effectiveness of any intervention to improve the appropriateness of future antimicrobial use.

Consequently, this study aims to: i) Develop the CAMUS using theoretical and contextual insights to assess knowledge, attitudes, and behaviors related to antimicrobial use in South African PHC settings, and ii) Pilot test the CAMUS and evaluate its feasibility and face validity in capturing actionable data to guide AMS interventions prior to full implementation in a larger population.

2 Materials and methods

2.1 Development of the CAMUS

The CAMUS, designed to capture the drivers of antimicrobial use, was developed to investigate and measure AMS related knowledge, attitudes and behaviors in South African PHC settings. The development process began with a scoping review to identify the key factors influencing antimicrobial use especially among patients (23). This review synthesized evidence from diverse contexts, highlighting themes such as perceptions of disease threat, social norms surrounding antibiotic use, and barriers to accessing appropriate healthcare (23). These findings informed the design of the CAMUS and emphasized the importance of grounding its constructs in established behavioral theories to ensure a comprehensive approach.

2.2 Theoretical framework

To comprehensively capture the cognitive, social, and contextual factors influencing antimicrobial use, the CAMUS was designed using constructs from three well-established health behavior theories:

- The HBM explains health behavior as a rational evaluation of perceived risks and benefits. It focuses on constructs such as perceived susceptibility, severity, benefits, barriers, and self-efficacy (38–41). In the CAMUS, the HBM informs items assessing patients' perceptions of risks associated with antimicrobial misuse, including beliefs about the efficacy of antibiotics for viral infections and the consequences of inappropriate use.
- The SCT emphasizes reciprocal determinism, the interaction between individual, environmental, and behavioral factors, and highlights self-efficacy, outcome expectations, and perceived facilitators and barriers (39). SCT constructs in the CAMUS assess behaviors such as purchasing antibiotics without prescriptions, prematurely discontinuing treatment, and the impact of external barriers like access to healthcare.
- The TpB links behavior to intentions shaped by attitudes, subjective norms, and perceived behavioral control (39–42). The CAMUS incorporates TpB constructs to explore patients' attitudes toward antibiotic use, the influence of societal norms and expectations, and their perceived ease or difficulty in adhering to appropriate practices.

2.3 Structure and dimensions of the CAMUS

The CAMUS was structured to assess four primary dimensions namely patients' knowledge, attitudes, motivations, and expectations related to antimicrobial treatments. These dimensions were derived from the scoping review themes and the theoretical framework:

- Knowledge: Assesses patients' understanding of antimicrobial use, including awareness of AMR and the appropriate indications for antimicrobials.

- Attitudes: Explores patients' perceptions and beliefs about antimicrobials, including their trust in healthcare providers and their views on self-medication.
- Motivations: Examines the factors driving decisions to use antimicrobials, such as past experiences, convenience, and societal or cultural influences.
- Expectations: Investigates patients' expectations regarding the effectiveness of antibiotics across a range of infectious diseases, particularly their beliefs about the necessity of antibiotics for treating self-limiting infections including colds, coughs and influenza.

By integrating these dimensions, the CAMUS captures the multifaceted drivers of antimicrobial use, guided by the constructs of the HBM, SCT, and TpB. For example, questions informed by the HBM address perceived risks and benefits of antibiotic use, while TpB shapes items on social norms and attitudes. SCT contributes insights into self-efficacy and barriers influencing behaviors such as adherence to prescribed treatments. By integrating theoretically grounded constructs and context-specific indicators, the CAMUS comprehensively captures key drivers of antimicrobial use. Its design ensures it is well-suited for evaluating knowledge, attitudes, motivations, and expectations related to antimicrobial use in South African PHC settings, providing a robust foundation for targeted AMS interventions in South Africa and wider across LMICs.

2.4 Methodology

2.4.1 Study design

This cross-sectional pilot study aimed to evaluate the feasibility and face validity of the CAMUS, which was designed to assess patients' knowledge, attitudes, motivations, and expectations regarding antimicrobial use. Cognitive interviews were conducted alongside the administration of the CAMUS to refine its design. Additionally, a health literacy test was administered to all participants prior to instigating the CAMUS to assess their ability to understand health-related information, which could influence their responses.

2.4.2 Study population

The study population consisted of adult patients attending public PHC facilities in two districts of South Africa.

2.4.2.1 Inclusion criteria

Participants were eligible for inclusion if they met the following criteria:

- Aged 18 years or older.
- Able to provide informed consent.
- Willing and able to participate in the interviewer-administered CAMUS and cognitive interview.
- Able to understand and communicate in English.

2.4.2.2 Exclusion criteria

Participants were excluded if they met any of the following criteria:

- Patients with severe illnesses requiring urgent medical attention or hospitalization.
- Individuals unable to understand or communicate in English.
- Patients unwilling to provide consent or participate in the study

2.4.3 Study site

The study was conducted in two phases, with the first phase conducted in a district in one province representing an urban population. For this phase of the study, urban areas included city, suburban, and township settings to capture a diverse range of healthcare access and living environments. The second phase was conducted in one district in another province representing a rural population.

2.4.4 Sample size and sampling technique

A total of 30 patients participated in this pilot study, with 30 patients chosen for this initial study building on our experiences with previous pilot studies undertaken in South Africa among patients and looking to add to this given the various strands of the questionnaire (17, 18).

- Phase 1: 15 patients were recruited from one urban district.
- Phase 2: 15 patients were recruited from one rural district in a different Province.

Participants were recruited using convenience sampling in the waiting areas of healthcare facilities. Patients sitting in the waiting area were approached and invited to participate in the study. Patients who met the inclusion criteria and provided informed consent were included in the study.

2.4.5 Data collection procedures

Phase 1 data collection in the urban district:

- A health literacy test was administered to all 15 participants before the CAMUS. Cognitive interviews were conducted alongside the administration of the CAMUS to evaluate clarity, comprehension, and relevance.
- Responses were analyzed to identify unclear or misinterpreted questions. Questions were refined based on the feedback to improve the CAMUS.

Phase 2 data collection in the rural district:

- The revised CAMUS was subsequently administered to another 15 participants, preceded by the health literacy test. Cognitive interviews were conducted to gather

additional feedback, and further adjustments to the CAMUS were made based on these insights.
- Additionally, a practical feasibility assessment was conducted on 5 participants in the rural district. These participants completed only the CAMUS to evaluate the time required for completion, ensuring its suitability for real-world PHC settings where time constraints are a significant consideration.

Data collection was carried out in a structured and systematic manner to ensure the accuracy and reliability of the information gathered. The following procedures were followed:

2.4.5.1 Participant recruitment and consent

In both districts, patients were approached in the waiting areas of PHC facilities. They were informed about the study's purpose, objectives, and procedures and invited to participate. Written informed consent was obtained from all participants before commencing any data collection activities. Participants were assured of confidentiality and anonymity throughout the study.

2.4.5.2 Health literacy assessment

Before administering the CAMUS, all participants completed a health literacy test adapted from the Health Literacy Test for Limited Literacy Populations (HELT-LL) (43). The test, used without modifications, assessed participants' ability to understand common medical instructions, prescription labels, and basic healthcare terminology. Based on their test scores, participants were categorized into three health literacy levels: inadequate (0–10), marginal (11–20), and adequate (21–24). These categorizations were used to contextualize participants' responses to the CAMUS.

2.4.5.3 Administration of the CAMUS and cognitive interviews

The CAMUS was administered to participants immediately following the health literacy test. It was conducted as an interviewer-administered survey to accommodate varying literacy levels and ensure accurate comprehension. Cognitive interviews were conducted concurrently with the CAMUS to evaluate participants' understanding and interpretation of the CAMUS items. Participants were asked follow-up questions to clarify their thought processes, identify any confusion or misinterpretation, and suggest improvements to the wording or structure of the questions.

All cognitive interviews and CAMUS responses were audiorecorded with participant consent to ensure accurate data capture and enable transcription and analysis.

In Phase 1, initial responses and cognitive interview feedback highlighted areas of ambiguity, leading to a revision of the CAMUS. In Phase 2, the refined CAMUS was administered to an additional cohort of participants, and further adjustments were made based on their feedback (see Section 2.5.2).

2.4.5.4 Feasibility assessment

In the rural district, a separate group of five participants completed the CAMUS without cognitive interviews to assess the time required for completion. This step evaluated the practical feasibility of implementing the CAMUS in real-world PHC settings, considering time constraints and patient engagement.

2.5 Data management and analysis

Data from the health literacy test, CAMUS responses, and cognitive interviews were captured into a Microsoft Excel spreadsheet for organization and analysis.

2.5.1 Health literacy test

Results were analyzed to understand participants' health literacy levels and their potential impact on the CAMUS responses. Descriptive statistics were used to summarize literacy levels across the sample.

2.5.2 Cognitive interviews

Recordings were transcribed to identify issues with question clarity and interpretation. This informed iterative refinements to the CAMUS after each phase.

2.5.3 CAMUS data

Quantitative data from the CAMUS were analyzed to assess knowledge, attitudes, motivations, and expectations regarding antimicrobial use. Descriptive statistics were used to summarize participant responses.

The average time to complete the CAMUS was calculated based on the feasibility assessment.

2.6 Ethical considerations

Ethical approval for this study was obtained from the Sefako Makgatho University Research Ethics Committee (SMUREC/P/220/2023). In addition, approval to conduct the study in the two provinces was granted by the respective provincial and district research committees. All patient responses were treated with strict confidentiality, and data will be securely stored in a password-protected database for a period of five years to ensure compliance with ethical standards and data protection protocols. Access to the data will be restricted to authorized research personnel only. In addition, no personal identifiable information will be included in reports or publications to safeguard participant confidentiality.

3 Results

30 participants took part in the pilot study, completing the health literacy assessment, the CAMUS and the cognitive interviews. An additional 5 participants completed the CAMUS only, in order to

determine the duration taken to complete the interview. These patients' responses are not included in the results presented.

Participant demographics are summarized in Table 1. Most participants had marginal health literacy (85.67%, n = 26), while only one participant had adequate health literacy. The majority of participants were female (66.67%, n = 20), with participants aged between 20 and 49 years, accounting for 80.0% (n = 24) of the study participants.

Just more than half (53.33%, n = 16) of participants resided in and were living in rural areas. All participants were African (100%, n = 30). In terms of marital status, 50% (n = 15) were single, and 90% (n = 27) had children.

The employed group was the largest (40%, n = 12) and 33.33% (n= 10) unemployed. With regards to educational level, 36.67% (n = 11) had completed high school and had a college or Further Education and Training (FET) qualification. Only 26.67% (n = 8) were trained in a health-related field, though 20.0% (n = 6) had family or friends that were healthcare workers.

When asked if participants had a name or term for antibiotics in their home or native language, 83.33% (n = 25) indicated that they did not have a term. The majority of participants (83.33%, n=25) reported to have used antibiotics at some point while 10% (n=3) claimed to have never used antibiotics. The majority (90.0%; n=27) of participants had never accessed antibiotics without a prescription, while 3 (10%) indicated that they accessed antibiotics without a prescription through a private or community pharmacy. These are pharmacies that provide medication and pharmaceutical services to local populations, including both independent and chain pharmacies (17).

3.1 Average time to complete the CAMUS

Five participants completed the CAMUS only to gauge the time it took to complete. On average it took 10 minutes to complete the CAMUS, see Table 2.

3.2 Cognitive interviews

In the first phase of cognitive interviews, feedback from the initial 15 participants led to revisions of 28 of the 30 questions and statements, ensuring they were clear and easy to understand. These adjustments, outlined in Table 3, focused on simplifying language and enhancing clarity. The revised items were then used in Phase 2 with 15 participants to confirm their usability. Only two questions/statements were revised after Phase 2 of data collection.

3.3 Antimicrobial knowledge

The results from the antimicrobial knowledge section (Table 4) highlights a mixed understanding of antibiotic use among participants. The majority of participants (60.0%, n=18) correctly

TABLE 1 Patient characteristics.

Variable	Characteristics	Frequency	Percentage
Health literacy classification	Adequate	1	3.33%
	Inadequate	3	10.00%
	Marginal	26	86.67%
	Grand Total	**30**	100.00%
Age	20-29	8	26.67%
	30-39	8	26.67%
	40-49	8	26.67%
	50-59	4	13.33%
	60-69	2	6.67%
	Grand Total	**30**	100.00%
Sex	Female	20	66.67%
	Male	10	33.33%
	Grand Total	**30**	100.00%
Ethnicity/race	African	30	100.00%
	Grand Total	**30**	100.00%
Geographic location	City	3	10.00%
	Rural area	16	53.33%
	Suburb	5	16.67%
	Township	6	20.00%
	Grand Total	**30**	100.00%
Marital status	Divorced/Separated	1	3.33%
	Living with partner	7	23.33%
	Married	7	23.33%
	Single	15	50.00%
	Grand Total	**30**	100.00%
Parental status	Do not have children	3	10.00%
	Have children	27	90.00%
	Grand Total	**30**	100.00%
Home language	Northern Sotho	13	43.33%
	Sesotho	3	10.00%
	Setswana	4	13.33%
	Swati	1	3.33%
	Tsonga	5	16.67%
	Venda	1	3.33%
	Zulu	3	10.00%
	Grand Total	**30**	100.00%
Employment status	Employed	12	40.00%
	Retired/pensioner	2	6.67%

(Continued)

TABLE 1 Continued

Variable	Characteristics	Frequency	Percentage
	Scholar	1	3.33%
	Self-employed	5	16.67%
	Unemployed	10	33.33%
	Grand Total	**30**	100.00%
Educational level	College or FET Qualification (Certificate)	11	36.67%
	High school completed	11	36.67%
	Other (specify)	2	6.67%
	Primary school completed	6	20.00%
	Grand Total	**30**	100.00%
Are you trained in a health-related field?	No	22	73.33%
	Yes	8	26.67%
	Grand Total	**30**	100.00%
If yes, which field	Hygiene in Hospital, Pharmacy, Personal Training, Community Healthcare Worker, Anova Health (HIV and related services), HIV councilor		
Is there a healthcare worker in your family or friends' group?	No	24	80.00%
	Yes	6	20.00%
	Grand Total	**30**	100.00%
Do you have a name or term for antibiotics in your home/ native language?	Don't know	1	3.33%
	No	25	83.33%
	Yes	4	13.33%
	Grand Total	**30**	100.00%
If yes, what is it?	Swtsongani; Agents of Ramaphosa, Methi – Medication; Can not recall the name, but there is; Dihlate tsa mashole a mmele		
How often do you use antibiotics?	Never	3	10.00%
	Rarely	2	6.67%
	Sometimes	25	83.33%
	Grand Total	**30**	100.00%
Have you ever paid for OR got antibiotics from somewhere without a prescription?	No	27	90.00%
	Yes	3	10.00%
	Grand Total	**30**	100.00%
If yes, from where?	Private/community pharmacy		

*Bolded values represent the total number of participants for each demographic variable.

recognized that antibiotics are effective against bacterial infections; however, there was confusion and misconceptions about their use for viral infections. Notably, 93.33% (n=28) incorrectly believed antibiotics treat colds and coughs, which are typically viral illnesses.

TABLE 2 Average time to complete interview.

Participant	Duration
Participant 1	9:22
Participant 2	8:47
Participant 3	12:17
Participant 4	10:46
Participant 5	8:48
Average	**10:00**

*Bolded value represents the average time.

While most coughs are viral in origin, certain bacterial infections, such as pertussis, do require antibiotic treatment. When asked explicitly, 50.0% of patients (n=15) believed that antibiotics treat viral infections and a further 23.33% (n=7) were uncertain.

Additionally, 56.67% (n=17) did not associate antibiotics with potential side-effects, indicating a gap in awareness about the possible risks of antibiotics. Understanding of specific conditions varied; while 70.0% (n=21) identified antibiotics as effective for urinary tract infections (UTIs), there was some misunderstanding regarding their use for other conditions. Notably, 30.0% (n=9) believed antibiotics were effective for treating diarrhea. While most cases of diarrhea are viral or self-limiting and require fluid replacement and supportive care, certain bacterial infections, such as *Shigella* or *Clostridium difficile*, may require antibiotic therapy. Additionally, 23.33% (n=7) expressed uncertainty regarding the appropriate treatment for diarrhea.

Regarding AMR, many participants showed an understanding of its causes, with 43.33% (n=13) recognizing that the overuse of antibiotics leads to resistance. However, some confusion persisted as 13.33% (n=4) were unsure about bacteria becoming resistant to antibiotics, 53.33% (n=16) indicated that bacteria do not become resistant to antibiotics and as mentioned, 93.33% (n=28) incorrectly believed antibiotics can treat viral infections such as colds and coughs. Overall, the findings suggest a need for targeted education to improve patients' and the public's knowledge about when antibiotics are appropriate, and the risks associated with their misuse.

3.4 Perceptions, attitudes, family and community behaviors and self-medication regarding antibiotics

The data in Table 5 shows a range of patient perceptions, attitudes, and behaviors regarding antibiotic use and healthcare provider roles in prescribing them. Of concern is that an appreciable portion of participants, 46.67% (n= 14), strongly agreed that they have the right to request antibiotics from their healthcare providers, with 10% (n= 3) moderately agreeing and 6.67% (n= 2) slightly agreeing. However, 16.67% (n= 5) strongly disagreed, indicating diverse opinions on patient agency in requesting antibiotics. This finding suggests that while some patients view antibiotic prescriptions as a right and expect

TABLE 3 Revised questions based on input from cognitive interviews.

No.	Original Question	Revised Question
1	Have you ever purchased or got antibiotics without a prescription	Have you ever paid for OR got antibiotics from somewhere without a prescription?
2	Are antibiotics effective (work successfully) in treating common colds and coughs?	Can you use antibiotics to cure/treat illnesses such as common colds and coughs
3	Do antibiotics have risks or negative side effects such as rash, headaches etc.?	Can antibiotics cause you to get/experience side effects such as rash or headaches?
4	Are antibiotics effective (work successfully) in treating diarrhea?	Can you use antibiotics to cure/treat diarrhea?
5	Are antibiotics effective (work successfully) in treating urinary tract infections?	Can you use antibiotics to cure/treat urinary tract infections or infections of the bladder?
6	Are antibiotics effective (work successfully) in treating all types of infections?	Can you use antibiotics to cure/treat all types of infections?
7	Are antibiotics effective (work successfully) in treating viral infections?	Can you use antibiotics to kill viruses in the body? [If the person does not know what a virus is, then explain: Viruses cause illness such as colds and flu]
8	Are antibiotics effective (work successfully) in treating bacterial infections?	Can you use antibiotics to kill bacteria in your body such as some ear infections or lung infections?
9	Do germs (bacteria) become resistant to antibiotics?	Can germs or bacteria become stronger than the antibiotic, so the antibiotic can't kill them anymore?
10	Does antimicrobial resistance occur when the body becomes resistant to antibiotics?	Do you think antimicrobial resistance means that the body gets used to the antibiotics and then the antibiotics do not work anymore to kill the germs?
11	Does the overuse and unnecessary use of antibiotics lead to antimicrobial resistance?	Do you think antimicrobial resistance means that if you take too much antibiotics, the germs in the body get used to it and will not be killed by the antibiotics anymore?
12	It is my right to ask for an antibiotic from my healthcare provider (healthcare professional - nurse or doctor).	I am allowed to demand that the healthcare provider (doctor/nurse) must give me antibiotics to treat my illness.
13	I expect my healthcare provider to explain when and why antibiotics are necessary or unnecessary.	I expect my healthcare provider to explain to me when and why antibiotics are necessary or not necessary to take.
14	By the time I am sick enough to see my healthcare provider, I expect a prescription for antibiotics.	By the time I am sick enough to see my healthcare provider (doctor/nurse), I expect (want/hope for) a prescription for antibiotics.
15	I expect to consult with my healthcare professional before taking antibiotics.	I expect to consult with or ask my healthcare professional (doctor/nurse) before taking antibiotics.
16	When my healthcare provider prescribes antibiotics, I expect to be involved in the decision-making process about my treatment	When my healthcare provider (doctor/nurse) prescribes antibiotics, I want to be part of the decision made about my treatment/medicines.
17	I believe that one should only take an antibiotic if it has been prescribed by a healthcare provider	I believe that one should only take an antibiotic if it has been prescribed by a healthcare provider (doctor or nurse)
18	My friends and/or family follow recommendations made by their healthcare provider for antibiotic use.	My friends and/or family listen to their healthcare provider (doctor/nurse/pharmacist) about how to use antibiotics.
19	My friends and/or family use antibiotics only when prescribed.	My friends or family use antibiotics only when prescribed by a doctor or a nurse.
20	My friends and/or family have purchased (bought) antibiotics from somewhere without a prescription.	My friends or family or colleagues at work buy antibiotics without them having a prescription.
21	My friends and/or family have recommended me to purchase/ buy antibiotics.	My friends and/or family have told me or suggest that I should buy antibiotics without having a prescription from a doctor or nurse.
22	I have been given antibiotics by my family or a friend or someone else in my household.	I have been given antibiotics to take by someone else I know, for example a family member, someone else in my household, a friend or a colleague at work.
23	In my community, it is common to use antibiotics without a prescription.	In my community or the area where I stay/work, it is common to use antibiotics without a prescription.
24	I have taken antibiotics without consulting a doctor/nurse at a healthcare facility.	I have taken antibiotics without consulting (being seen by) a doctor/nurse at a healthcare facility.
25	I have kept leftover or unused antibiotics that have been prescribed for me or my family, for future use.	I have kept leftover antibiotics (antibiotics not taken) that have been prescribed for me or my family, so that we can use it again in the future.
26	I have used antibiotics that were prescribed for someone else.	I have used/taken antibiotics that were prescribed for someone else

(Continued)

TABLE 3 Continued

No.	Original Question	Revised Question
27	I have shared antibiotics with someone else who had not been prescribed antibiotics.	I have shared (given) antibiotics that I had, with someone else who had not been prescribed antibiotics.
28	I stop taking antibiotics when my symptoms resolve even if the course has not been completed.	I stop taking antibiotics when my symptoms go away, even if all the pills/capsules I have been given are not finished yet.

healthcare providers to comply with their requests, others acknowledge the prescriber's authority in determining the necessity of antibiotics. This variation highlights the potential influence of patient expectations on prescribing practices and the need for patient education on appropriate antibiotic use. When it comes to symptom relief, half of the participants (50.0%, n= 15) strongly expect antibiotics to quickly alleviate their symptoms with only 20.0% (n= 6) strongly disagree with this expectation, reflecting some awareness that antibiotics may not always lead to immediate relief.

Trust in healthcare providers' judgment was notably high, with 86.67% (n= 26) strongly agreeing that their providers should decide when antibiotics are necessary, underscoring the participants' reliance on professional guidance. Furthermore, 80.0% (n= 24) strongly agree that they expect their providers to explain the necessity or lack thereof for antibiotic prescriptions, highlighting a strong desire for communication and understanding in the decision-making process. Having said this, a notable number of participants, 40.0% (n= 12) strongly agreed that by the time they seek medical attention, they expect a prescription for antibiotics, though 30% (n= 9) strongly disagreed showing divided expectations about receiving antibiotics when ill.

A majority (90.0%, n= 27) strongly agreed that they should consult their healthcare professional before taking antibiotics, underscoring a preference for professional guidance. Similarly, 86.67% (n= 26) strongly believe that antibiotics should only be taken if prescribed by a healthcare provider, reinforcing strong adherence to prescription-based use.

However, attitudes about treatment decisions and adherence to antibiotic courses varied. While 33.33% (n= 10) strongly agreed that they expect to be involved in treatment decisions, 36.67% (n= 11) strongly disagreed, indicating mixed preferences regarding patient-provider decision-making involvement. Additionally, 50.0% (n= 15) strongly disagreed with stopping antibiotics once symptoms resolve, suggesting that there is a keen understanding the importance of completing the full course. Having said this, 30.0% (n= 9) admitted they would stop antibiotics early when feeling better, highlighting an area for educational reinforcement.

The majority of participants (73.33%, n=22) strongly agreed that their friends and family follow healthcare provider recommendations for antibiotic use, and 66.67% (n=20) strongly agreed that antibiotics are only taken when prescribed. This suggests that adherence to prescription-based use is commonly valued within these social circles. However, certain behaviors show deviations. While 56.67% (n=17) strongly disagreed that their friends or family have bought antibiotics without a prescription, 16.67% (n=5) strongly agreed that this has occurred, and 20.0% (n=6) also report being encouraged by friends or family to purchase antibiotics without a prescription, although 60.0% (n=18) strongly disagreed with these practices. Perceptions of community norms further reinforce these findings. Half, 50.0% (n=15), of participants strongly disagreed that non-prescription antibiotic use is common in their community, though 16.67% (n=5) strongly agreed. These results highlight both adherence to healthcare provider guidance and variability in behaviors around prescription adherence, influenced by family or community practices.

TABLE 4 Antimicrobial knowledge.

Statement posed to participants	Yes	No	Don't know
Are antibiotics effective (work successfully) in treating common colds and coughs?	28 (93.33%)	0 (0%)	2 (6.67%)
Do antibiotics have risks or negative side effects such as rash, headaches etc.?	8 (26.67%)	17 (56.67%)	5 (16.67%)
Are antibiotics effective (work successfully) in treating diarrhea?	9 (30%)	14 (46.67%)	7 (23.33%)
Are antibiotics effective (work successfully) in treating urinary tract infections?	21 (70%)	4 (13.33%)	5 (16.67%)
Are antibiotics effective (work successfully) in treating all types of infections?	14 (46.67%)	13 (43.33%)	3 (10%)
Are antibiotics effective (work successfully) in treating viral infections?	15 (50%)	8 (26.67%)	7 (23.33%)
Are antibiotics effective (work successfully) in treating bacterial infections?	18 (60%)	5 (16.67%)	7 (23.33%)
Do germs (bacteria) become resistant to antibiotics?	10 (33.33%)	16 (53.33%)	4 (13.33%)
Does antimicrobial resistance occur when the body becomes resistant to antibiotics?	8 (26.67%)	10 (33.33%)	12 (40%)
Does the overuse and unnecessary use of antibiotics lead to antimicrobial resistance?	13 (43.33%)	9 (30%)	8 (26.67%)

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TABLE 5 Perceptions, attitudes, family and community behaviors and self-medication regarding antibiotics.

Category	Statement posed to participants	Responses: n (%)						
		Strongly agree	Moderately agree	Slightly agree	Neutral	Slightly disagree	Moderately disagree	Strongly disagree
Perceptions regarding antibiotics	It is my right to ask for an antibiotic from my healthcare provider (healthcare professional - nurse or doctor).	14 (46.67%)	3 (10%)	2 (6.67%)	4 (13.33%)	2 (6.67%)	0 (0%)	5 (16.67%)
	I expect antibiotics to quickly relieve my symptoms.	15 (50%)	3 (10%)	4 (13.33%)	0 (0%)	1 (3.33%)	1 (3.33%)	6 (20%)
	I trust my healthcare provider to decide whether he/she needs to prescribe antibiotics for my condition.	26 (86.67%)	2 (6.67%)	1 (3.33%)	1 (3.33%)	0 (0%)	0 (0%)	0 (0%)
	I expect my healthcare provider to explain when and why antibiotics are necessary or unnecessary.	24 (80%)	2 (6.67%)	3 (10%)	1 (3.33%)	0 (0%)	0 (0%)	0 (0%)
Attitudes towards antibiotics	By the time I am sick enough to see my healthcare provider, I expect a prescription for antibiotics.	12 (40%)	2 (6.67%)	4 (13.33%)	1 (3.33%)	1 (3.33%)	1 (3.33%)	9 (30%)
	I expect to consult with my healthcare professional before taking antibiotics.	27 (90%)	1 (3.33%)	1 (3.33%)	0 (0%)	0 (0%)	0 (0%)	1 (3.33%)
	When my healthcare provider prescribes antibiotics, I expect to be involved in the decision-making process about my treatment	10 (33.33%)	2 (6.67%)	2 (6.67%)	4 (13.33%)	0 (0%)	1 (3.33%)	11 (36.67%)
	I believe that one should only take an antibiotic if it has been prescribed by a healthcare provider	26 (86.67%)	1 (3.33%)	0 (0%)	3 (10%)	0 (0%)	0 (0%)	0 (0%)
	I stop taking antibiotics when my symptoms resolve even if the course has not been completed.	9 (30%)	0 (0%)	0 (0%)	2 (6.67%)	2 (6.67%)	2 (6.67%)	15 (50%)
Family and community behaviours	My friends and/or family follow recommendations made by their healthcare provider for antibiotic use.	22 (73.33%)	1 (3.33%)	0 (0%)	6 (20%)	1 (3.33%)	0 (0%)	0 (0%)
	My friends and/or family use antibiotics only when prescribed.	20 (66.67%)	3 (10%)	1 (3.33%)	5 (16.67%)	0 (0%)	0 (0%)	1 (3.33%)
	My friends and/or family have purchased (bought) antibiotics from somewhere without a prescription.	5 (16.67%)	0 (0%)	0 (0%)	4 (13.33%)	4 (13.33%)	0 (0%)	17 (56.67%)
	My friends and/or family have recommended me to purchase/ buy antibiotics.	6 (20%)	0 (0%)	0 (0%)	2 (6.67%)	2 (6.67%)	2 (6.67%)	18 (60%)
	In my community, it is common to use antibiotics without a prescription.	5 (16.67%)	1 (3.33%)	0 (0%)	7 (23.33%)	1 (3.33%)	1 (3.33%)	15 (50%)
Self-medication and sharing of antibiotics	I have been given antibiotics by my family or a friend or someone else in my household.	7 (23.33%)	1 (3.33%)	1 (3.33%)	3 (10%)	0 (0%)	2 (6.67%)	16 (53.33%)
	I only take antibiotics if they have been prescribed by a doctor or nurse	23 (76.67%)	2 (6.67%)	2 (6.67%)	2 (6.67%)	0 (0%)	0 (0%)	1 (3.33%)
	I have taken antibiotics without consulting a doctor/nurse at a healthcare facility.	5 (16.67%)	2 (6.67%)	1 (3.33%)	1 (3.33%)	0 (0%)	1 (3.33%)	20 (66.67%)

(Continued)

TABLE 5 Continued

Category	Statement posed to participants	Responses: n (%)						
		Strongly agree	Moderately agree	Slightly agree	Neutral	Slightly disagree	Moderately disagree	Strongly disagree
	I have kept leftover or unused antibiotics that have been prescribed for me or my family, for future use.	5 (16.67%)	2 (6.67%)	1 (3.33%)	2 (6.67%)	2 (6.67%)	1 (3.33%)	17 (56.67%)
	I have used antibiotics that were prescribed for someone else.	7 (23.33%)	1 (3.33%)	0 (0%)	0 (0%)	1 (3.33%)	1 (3.33%)	20 (66.67%)
	I have shared antibiotics with someone else who had not been prescribed antibiotics.	7 (23.33%)	0 (0%)	0 (0%)	0 (0%)	1 (3.33%)	1 (3.33%)	21 (70%)

With regards to self-medication and the sharing of antibiotics, most participants (66.67%, n=20) strongly disagreed with taking antibiotics without consulting a healthcare provider, indicating a strong preference for professional guidance. Similarly, a significant majority (76.67%, n=23) strongly agreed that they only take antibiotics if prescribed by a doctor or nurse, showing adherence to prescription-based use of antibiotics. Despite this adherence, certain behaviors show deviation. For instance, 16.67% (n=5) strongly agreed that they have kept leftover antibiotics for future use, while 56.67% (n=17) strongly disagreed, indicating mixed practices regarding leftover medication. Additionally, 23.33% (n=7) strongly agreed that they have used antibiotics prescribed for someone else, although the majority (66.67%, n=20) strongly disagreed. Antibiotic sharing appears to be limited. A large majority, 70.0% (n=21), strongly disagreed with sharing antibiotics with others who were not prescribed antibiotics. Likewise, 53.33% (n=16) strongly disagreed with receiving antibiotics from friends or family. However, a notable 23.33% (n=7) strongly agreed, suggesting a potential source of antibiotics within households.

4 Discussion

This study successfully developed, and pilot tested the CAMUS, designed to assess patients' knowledge, attitudes, motivations, and behaviors related to antimicrobial use in South African PHC settings. The results demonstrate the potential of the CAMUS to capture the nuanced factors influencing antimicrobial use, providing actionable insights to guide AMS initiatives, which is important for South Africa as well as other African countries given concerns with rising AMR rates in this sub-continent (4, 5, 10, 17).

A notable finding was the prevalence of marginal health literacy among participants (86%), which aligns with previous studies linking limited health literacy to poorer understanding of antibiotic use and AMR in LMICs (44, 45). This underscores the importance of ensuring that health education and AMS interventions are accessible to patients with varying literacy levels. The CAMUS, with its iterative refinements based on cognitive interviews, addresses this challenge by simplifying language and enhancing clarity.

Misconceptions about antibiotic use were evident, with 93.33% (n=28) of participants incorrectly believing that antibiotics can treat common colds and coughs, which are typically viral illnesses. Additionally, 50.0% (n=15) believed that antibiotics could treat viral infections, while 23.33% (n=7) were uncertain. Regarding antibiotic adherence, 30.0% (n=9) of participants indicated that they would stop taking antibiotics once symptoms improved, which reflects a significant misconception about appropriate antibiotic use. This finding is consistent with other studies in South Africa and LMICs that report widespread misunderstanding of antibiotic efficacy and use (45–50). However, the recognition of AMR causes, including the overuse of antibiotics, among 43.33% of participants suggests a partial understanding of the issue. These combined findings highlight the importance of targeted education to bridge knowledge gaps and promote appropriate antibiotic use through AMS (12, 50–52). However, it is important to consider potential language barriers, particularly in cases where there are no specific terms for words such as antibiotics and AMR in certain populations and languages in South Africa and beyond (17, 18, 36, 53). We will be exploring the implications further for all key stakeholder groups in South Africa building on the suggestions from our previous work (9, 10, 17).

The study findings suggest that CAMUS can serve as a valuable tool in AMS initiatives by identifying key knowledge gaps and behavioral patterns related to antimicrobial use. Implementing CAMUS within PHC settings could enable targeted patient education, and guiding tailored interventions to correct misconceptions. Additionally, integrating CAMUS findings into provider training programs may help healthcare professionals address patient expectations regarding antibiotic prescriptions more effectively. Future studies should explore how CAMUS-based interventions impact antimicrobial use behaviors over time.

The demographic diversity of the sample, including participants from both urban and rural settings, provided insights into regional variations in antimicrobial use behaviors. However, the small sample size of this pilot study limits the generalizability of these findings, warranting further research with larger and more representative populations.

The CAMUS theoretical foundation, drawing on the HBM, SCT, and the TpB, ensured that it captured cognitive, social, and systemic drivers of antimicrobial use. For example, constructs addressing perceived risks, social norms, and self-efficacy were effectively incorporated, enabling a comprehensive assessment of key behavioral determinants. The CAMUS also demonstrated its reliability and feasibility in PHC settings, with participants completing the interview in an average of 10 minutes. The integration of cognitive interviews further enhanced its usability by addressing potential ambiguities and tailoring items to the local context, which is important going forward.

A limitation of this study in particular is that CAMUS was tested only in English, which may restrict its applicability in South Africa's multilingual context. Many South African populations may not have precise terminology for terms such as 'antibiotics' or 'antimicrobial resistance' in their native languages, potentially impacting comprehension and response accuracy. However, because CAMUS is a new tool, validation in English should precede translation to other languages with subsequent validation. As CAMUS relies on self-reported data, there is also potential for recall and social desirability biases. Future studies should focus on firstly using CAMUS in a much larger and more diverse population to develop a shorter version of CAMUS (possibly 10 items) which will best predict AMS-related use behaviors. Thereafter, translating the shorter version into multiple local languages, and refining its applicability to different healthcare settings. It is envisaged that the shorter version will be quick and easy to administer.

Bearing in mind that this was only a pilot study, another potential limitation of the study is the presence of bias due to the fact that nearly one-third of participants had received health-related education. Participants with prior health-related training may have had greater baseline knowledge of antimicrobial use, which could have influenced their responses and potentially overestimated the level of understanding in the broader population. This may limit the generalizability of the findings to individuals without a healthcare background. Future studies should aim to balance participant demographics by including a more representative sample of the general population to minimize this potential bias and ensure the CAMUS is tested across a diverse range of knowledge levels.

If validated in larger populations, CAMUS could serve as a valuable tool to support AMS initiatives by providing data on patient knowledge, attitudes and behaviors. This information could help shape targeted educational interventions, guide healthcare provider communication strategies, and inform regulatory policies aimed at reducing inappropriate antimicrobial use in PHC settings.

Future studies with larger and more diverse samples will now take place to validate the CAMUS findings and identify the items that will best predict AMS-related behavior. As mentioned, we are aware that the CAMUS was only tested in English, potentially limiting its applicability in South Africa's multilingual context (18, 24). Consequently, validation in local languages will also take place to ensure its broader relevance and utility. Hence, future research will involve translating and adapting the CAMUS into multiple local languages. This process will incorporate a rigorous translation and back-translation methodology, cognitive testing, and cultural adjustments to ensure broader relevance. This is important across Africa given the many languages that can exist in a number of African countries. While the data should be interpreted with caution as this was a pilot study with the aim of testing the questionnaire, we believe the findings from this pilot study are robust, providing direction for further studies with larger populations in South Africa and wider.

5 Conclusion

The CAMUS demonstrated its relevance and usefulness in capturing key constructs related to antimicrobial use behaviors in South African PHC settings. Pilot testing confirmed its feasibility, and face validity, with iterative refinements improving clarity and comprehension. The tool provides a structured method for assessing patient knowledge, attitudes, and behaviors, which can contribute to improving AMS efforts.

A key strength of this pilot was the use of cognitive interviews, which enhanced the clarity and relevance of the questionnaire. While this study was limited in scope, the findings support further validation of CAMUS in larger and more diverse populations. Future research should focus on shortening, refining and validating the tool across multiple settings to ensure its applicability and effectiveness in guiding AMS initiatives.

Next steps will include scaling up the validation process, incorporating a possibly shorter scale in diverse linguistic and cultural contexts, and evaluating CAMUS in broader healthcare environments. Ensuring its usability across different healthcare settings will be essential for optimizing its role in addressing inappropriate antimicrobial use and supporting AMS strategies which are very necessary to meet the new United Nations Global Assembly targets for AMR going forward.

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 authors.

Ethics statement

The studies involving humans were approved by 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

NR: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing – original draft, Writing – review & editing. TB: Data curation, Formal analysis, Investigation, Validation, Writing – review & editing. MT: Data curation, Formal analysis, Investigation, Validation, Writing – review & editing. MS: Conceptualization, Formal analysis, Methodology, Resources, Validation, Writing – review & editing. TS: Conceptualization, Methodology, Validation, Writing – review & editing. SC: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Writing – review & editing. NS: Conceptualization, Methodology, Supervision, Visualization, Writing – review & editing. BG: Conceptualization, Methodology, Supervision, Validation, Writing – review & editing. JM: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – review & editing.

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