

Implementing a community-based antimicrobial stewardship intervention in Malaysia

Ali Haider Mohammed^{1,2} , Angelina Lim^{3,4},
Bassam Abdul Rasool Hassan², Ali Blebil^{1,2}, Juman Dujaili^{1,2,5},
Dinesh Sangarran Ramachandram¹, Hawar Sardar Hassan^{6,7} and
Arooj Abid⁸ 

Journal of Infection Prevention

2024, Vol. 0(0): 1–11

© The Author(s) 2024



Article reuse guidelines:

sagepub.com/journals-permissions

DOI: 10.1177/17571774241251650

jip.sagepub.com

Abstract

Background: In Malaysia, the unregulated use of antibiotics and lack of awareness about antimicrobial resistance (AMR) among pharmacists pose significant challenges. Implementing community-based Antimicrobial Stewardship (AMS) initiatives is crucial to address the rising AMR.

Methods: We developed a bespoke AMS intervention, aligned with the World Health Organization's AMS modules, as a 2-day online educational seminar for community pharmacists. The effectiveness of the workshop was evaluated using pre- and post-seminar questionnaires, focusing on AMS knowledge and attitudes towards antimicrobial usage.

Results: Among 528 participants, 489 completed both questionnaires. Pre-seminar, only 59% correctly understood the concept of antibiotic resistance reversibility, which improved to 85.9% post-seminar ($p = .002$). The average AMS knowledge score increased from 5/10 to 8/10 post-intervention ($p < .05$). A significant improvement was also noted in pharmacists' ability to select appropriate antibiotic therapies, particularly for urinary tract infections, with an increase from 78% to 90% correct responses.

Conclusion: The AMS seminar was well-received and significantly improved the AMS knowledge of community pharmacists. The results underline the need for more AMS-focused interventions in this demographic in Malaysia, contributing to the development of formalized AMS programs. Such initiatives are expected to enhance antibiotic use awareness, encourage optimal antibiotic practices, and positively shift professional conduct in community settings.

Keywords

Antimicrobial stewardship, community pharmacy practice, antimicrobial resistance education and training, antibiotic resistance prevention, Malaysia healthcare system

Date received: 16 May 2023; accepted: 13 April 2024

Introduction

Antimicrobial resistance (AMR) has surfaced as a critical issue challenging healthcare systems globally in the 21st century (1). AMR occurs when microorganisms adapt, developing resistance to medications, leading to infections that become difficult to treat and increasing the risk of spreading these resistant organisms, often called “superbugs,” within communities (Rochford et al., 2018). This resistance has contributed to increased death rates, longer hospital stays, and higher healthcare costs due to infections caused by bacteria that resist multiple drugs (Dadgostar, 2019; Rochford et al., 2018). A 2019 global report estimated

¹School of Pharmacy, Monash University Malaysia, Bandar Sunway, Malaysia.

²Department of Pharmacy, Al-Rafidain University College, Baghdad, Iraq.

³Faculty of Pharmacy and Pharmaceutical Sciences Monash University, Clayton, VIC, Australia.

⁴Murdoch Childrens Research Institute, Royal Children's Hospital, Parkville, VIC, Australia.

⁵Swansea University Medical School, Swansea University, Swansea, UK.

⁶Department of Dentistry, Komar University of Science and Technology, Kurdistan-Region, Iraq.

⁷Department of Radiology, Anwar-Sheikha Medical City, Kurdistan Region, Iraq.

⁸Department of Public Health, Health Services Academy, Islamabad, Pakistan.

Corresponding author:

Ali Haider Mohammed, School of Pharmacy, Monash University Malaysia, Subang Jaya, Bandar Sunway 47500, Malaysia.

Emails: alihaider.mohammed@monash.edu, alishanshool93@gmail.com

that about 5 million individuals contracted serious infections from antibiotic-resistant bacteria, resulting in at least 1.27 million deaths annually (Morrison and Zembower, 2020; Rochford et al., 2018). With antibiotics widely available and frequently used, resistance has been escalating, especially in developing countries, where misuse of these drugs is common (Boolchandani, D'Souza and Dantas, 2019). As resistance grows, first-choice antibiotics lose effectiveness, requiring more toxic and expensive alternative treatments (Getahun et al., 2020). In Malaysia, a significant 16% rise in annual antimicrobial usage was recorded between 2009 and 2010. Moreover, patients needing systemic antibiotic therapy typically face the highest healthcare costs (Hofer, 2019). Hence, there is a pressing need for more effective antibiotic use strategies (Hofer, 2019).

Antimicrobial Stewardship programs are pivotal in countering AMR and curbing antibiotic overuse. AMS involves the careful and responsible management of antimicrobial medications (Hofer, 2019). The key components of AMS include monitoring antibiotic use, educating healthcare providers and patients, implementing targeted interventions, and establishing leadership roles to ensure accountability in antibiotic prescribing and usage (Akpan et al., 2020; Nathwani et al., 2019).

In Malaysia, antibiotics are supposed to be prescribed by doctors or dispensed by community pharmacists with a valid prescription (Bo et al., 2022). However, the verification of appropriate antibiotic use is often inadequate, and there have been instances of community pharmacists dispensing antibiotics without a prescription. This highlights an urgent need for AMS initiatives within the community pharmacy setting in Malaysia, where there is a lack of interventional AMS studies and minimal literature on AMS knowledge among community pharmacists (Erku, 2016). While AMS programs have been effectively introduced in other countries (Saha et al., 2019), this research aims to assess the impact of an online, live AMS educational workshop, based on WHO recommendations (Akpan et al., 2020; World Health Organization, 2019a), on the AMS understanding and antibiotic selection practices of community pharmacists.

Methods

Study design and study participants

The research was structured as a pre- and post-intervention study, centering on an online AMS educational workshop conducted over 2 days in November 2022 as the intervention. Community pharmacists across Malaysia were invited to participate through emails and announcements posted in social media groups tailored for community pharmacists on platforms like Facebook® and Telegram®. Eligible participants were those i) registered with the Pharmacy Board of Malaysia and ii) actively employed (part-time or full-time) in a community pharmacy setting. Interns, recent graduates, and those unwilling to engage in

the study were excluded. The efficacy of the intervention was assessed via pre- and post-workshop questionnaires. Invitations for the workshop were disseminated starting from October 1, 2022, with a closing date for registrations on November 5, 2022. The workshop itself was conducted over 2 days, on November 12 and 13, 2022. This timeline from the invitation to the workshop attendance ensures adequate time for pharmacists to register and prepare for the event. The sample size be calculated based on the number of community pharmacists in the population, which is 3892 (Erku, 2016). According to the Raosoft Sample Size Calculator, using a population size of 3892 community pharmacists and a response distribution of 50%, these parameters were chosen to ensure a robust and reliable sampling strategy, balancing accuracy with feasibility. Based on these inputs, the Raosoft calculator recommended a minimum sample size of 350 participants. This size is deemed sufficient to confidently represent the views and practices of the community pharmacist population in Malaysia while maintaining a high standard of statistical validity.

Pre- and Post-questionnaire development

The pre- and post-questionnaire was approximately 10 min long and consisted of multiple-choice and short answer items, and it was adapted using previous AMS knowledge questionnaires (Erku, 2016; Sarwar et al., 2018; Tahoon et al., 2020). The pre- and post-questionnaire was the same, with the exception that the post-questionnaire also requested an evaluation of the workshop itself and satisfaction with the intervention. It is pertinent to note that the content validation was undertaken by three practicing clinical pharmacists, each possessing over a decade of experience in AMS and infectious diseases. Their extensive experience ensured the relevance and accuracy of the questionnaire. The pilot testing was put through a Cronbach's alpha reliability test, which returned a value of 0.878, indicating that it is reliable and has good internal consistency. There are four distinct parts to the English-language questionnaire. The first part of the questionnaire included demographics (gender, age, level of education, years of experience, and description of place of practice). The second part focused on testing AMR and AMS knowledge using case scenarios. The third part measured pharmacists' attitude towards AMS using a 5-point Likert scale (5: strongly agree, 4: agree, 3: neutral, 2: disagree, and 1: strongly disagree). Lastly, the fourth component measured confidence in determining the most appropriate antibiotic medication using four simulated cases from a community pharmacy (viral conjunctivitis, cellulitis, tooth infection, and urinary tract infection). Each response deemed most appropriate to a knowledge question resulted in a one-point score for the participant; no deductions were given to errors/inappropriate/inappropriate suggestions. The total knowledge score was then converted to a scale from 0 to 10. The pharmacists were given the pre-workshop

questionnaire using an online link 20 min before the start of the workshop; if the form hadn't been completed by then, the link would have been disabled. At the end of the workshop, the same group of participants was given the same survey link as the post-questionnaire.

Educational workshop

The AMS online, live, educational workshop took place over the course of two sessions on Saturday, November 12, and Sunday, November 13, 2022. Zoom was the virtual platform used to host the meetings. PowerPoint presentations, films, and clinical case scenarios were delivered during the course of each session's 90 min. The workshop content was developed with input from the WHO's online AMS training modules (Stewardship WA, 2020). Two clinical pharmacists with over 10 years of expertise in the field of infectious diseases reviewed the authors' work and provided feedback before it was published. The educational workshop was delivered by a team of four expert presenters, comprising two clinical pharmacists specialized in infectious diseases, a microbiologist, and an AMS program coordinator. Each presenter brought unique insights and expertise, enriching the workshop's content and delivery. Theoretical topics including (1) antibiotic fundamentals and therapeutic concepts, (2) AMR, (3) AMS, and (4) the pharmacist's involvement in stewardship programs were covered in four separate presentations. During the first session of the course, pharmacists discussed a booklet containing infection guidelines, including those for respiratory infections, skin infections, and urinary tract infections. The pre-workshop questionnaire was provided to participants 20 min prior to the commencement of the workshop, with a stipulation that it must be completed before the link was disabled. Conversely, the post-workshop questionnaire was distributed immediately after the workshop's conclusion, with participants allotted 30 min to complete it. This precise timing ensures a focused and prompt assessment of the workshop's impact. The participation in this workshop was free of charge, and there was no incentive to be given for participation. The participation in this study was completely voluntary, and if any of them decided not to participate there would not be any negative consequences. Participants were also informed that they may stop participating at any time (before or during the start of answering the questionnaire), and if they did so, their responses would not be counted.

Data analysis

The analysis of the data was performed with SPSS version 22. During the descriptive analysis, researchers used measures like mean and SD for the continuous variables and percentages for the qualitative ones. Shapiro-Wilk test (where $p > .05$ indicates normally distributed continuous

variable) was used to check for normality. The pre-workshop and post-workshop differences in continuous variables were analyzed using the Wilcoxon sign rank test, while the differences in categorical variables were analyzed using McNemar's test. Values of Cronbach's over 0.7 suggest sufficient internal consistency in the questionnaire (Association GAotWM, 2014). All tests were two-tailed, and a p -value of less than 0.05 was considered statistically significant as shown in Figure 1.

Results

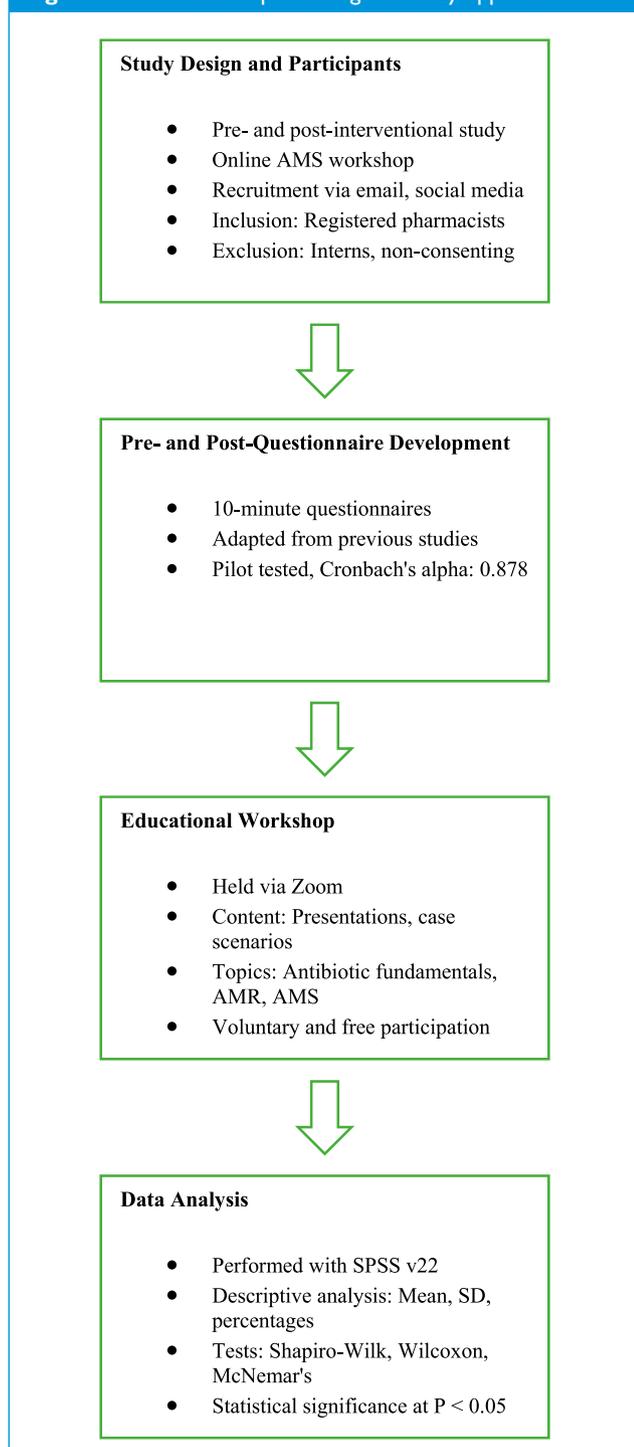
Socio-demographics

Five hundred twenty community pharmacists attended the training. However, 489 of them filled out the questionnaire completely before and after the workshop (a completion rate of 94%). The average age of the study participants was 32.6 years (SD 7.5), the vast majority were male ($n = 359$, 73.4%), and 84.8% had at least a baccalaureate degree in pharmacy ($n = 415$). The majority of participants ($n = 340$, 69.5%) worked in private, independent pharmacies, while the remainder 30.5% ($n = 149$) are employed by national or regional pharmacy chains. Almost 31% of the participants ($n = 139$) said they have attended an AMS-related session in the past. Table 1 displays the detailed sociodemographic data.

Awareness about AMS

Participants were polled on where they learnt about antibiotics and proper antibiotic usage (Figure 2). The majority of participants ($n = 445$, 91%) reported using either clinical textbooks ($n = 420$, 85.9%) or an up-to-date database ($n = 410$, 83.8%). In terms of what resources participants use, the majority used PubMed ($n = 380$, 76.7%) and clinical guidelines including Malaysian National Antimicrobial Guideline (NAG) and WHO guidelines ($n = 370$, 75.6%), respectively. At the same time, half of the participants relied on the Internet or social media for research purposes, with sources including coworkers ($n = 315$, 64.40%), university lecture notes ($n = 289$, 63.4%), and social media ($n = 295$, 49.0%).

Part two of the pre- and post-questionnaire findings based on AMS knowledge is detailed in Table 2. Overall, most pharmacists reported learning new information from the workshop. During pre-surveys, only 77.7% ($n = 380$) of respondents most appropriately identified the falsehood of the statement "purpose of AMS is to encourage over the counter prescription of antibacterial agents"; however post-surveys, this number had increased to 99.7% ($n = 488$) ($p = .043$). The median participant knowledge score increased from 7 (IQR = 5) before the session to 8 (IQR = 6) after the workshop ($p = .003$). Table 2 and Figure 3 provide further information.

Figure 1. Flowchart representing the study approach.

Pharmacists' ability to appropriately select most appropriate antibiotic therapy for virtual community pharmacy cases

Figure 4 elucidates the outcomes from the fourth section of the questionnaire, which focused on empirical therapy preferences across four clinical scenarios. The data reveals a

notable enhancement in participants' aptitude for selecting accurate antibiotic therapy for urinary tract infections (UTIs). Prior to the workshop, 79.7% ($n = 390$) of participants most appropriately identified the appropriate therapy, a figure which escalated to 89.9% ($n = 440$) post-workshop, a statistically significant increase ($p = .003$). Similarly, for bacterial sinusitis, initial proficiency was observed at 57.2% ($n = 280$) among pharmacists in most appropriately determining the non-necessity of antibiotics for viral conjunctivitis. This percentage improved to 65.4% ($n = 320$) following the workshop, marking a statistically significant enhancement ($p = .048$). Notably, pharmacists also demonstrated statistically significant improvements in their responses to the other two clinical situations—dental infections and cellulitis—after participating in the training ($p < .05$).

In summary, Figure 4 highlights the significant improvement in the ability of community pharmacists to appropriately select the most appropriate antibiotic therapy for various community-based clinical cases, both before and after attending the educational workshop. The improvements were statistically significant across all cases: UTI ($p = .003$), tooth infection ($p = .025$), cellulitis ($p = .001$), and viral conjunctivitis ($p = .048$).

There were seven statements used to evaluate pharmacists' attitudes towards the AMS program; most respondents had a very positive attitude towards the programs both before and after the workshop, with significant changes in their responses after the workshop ($P < 0.05$ for all statements). Sixty-three percent of participants ($n = 305$) agreed that they should play a pivotal role in antibiotic stewardship and infection prevention. After attending the workshop, this figure rose to 79.7% ($n = 390$). In addition, 69.5% of participants ($n = 340$) agreed/strongly agreed that community pharmacists should have appropriate knowledge on AMS, and this number was increased to 83.8% ($n = 410$) after the workshop, showing that community pharmacists understand the significance of the stewardship program (Table 3; Figure 5).

In a nutshell, the educational initiative appears to have significantly bolstered the community pharmacists' awareness and understanding of antimicrobial resistance and stewardship, as evidenced by the comparative analysis of pre- and post-workshop knowledge assessments. Notably, there was an appreciable elevation in most appropriate responses post-intervention, with the acknowledgment of broad-spectrum antibiotics usage to mitigate resistance increasing from 51.1% to 63.3%, and the recognition of AMS's role in enhancing therapeutic efficacy advancing from 76.6% to 85.8%. Additionally, the pharmacists' perception of their pivotal role in AMS and infection prevention was markedly reinforced, rising from 62.3% in agreement pre-workshop to 79.7% post-workshop. The overwhelming satisfaction with the workshop's content and delivery underscores the program's effectiveness, corroborated by near-

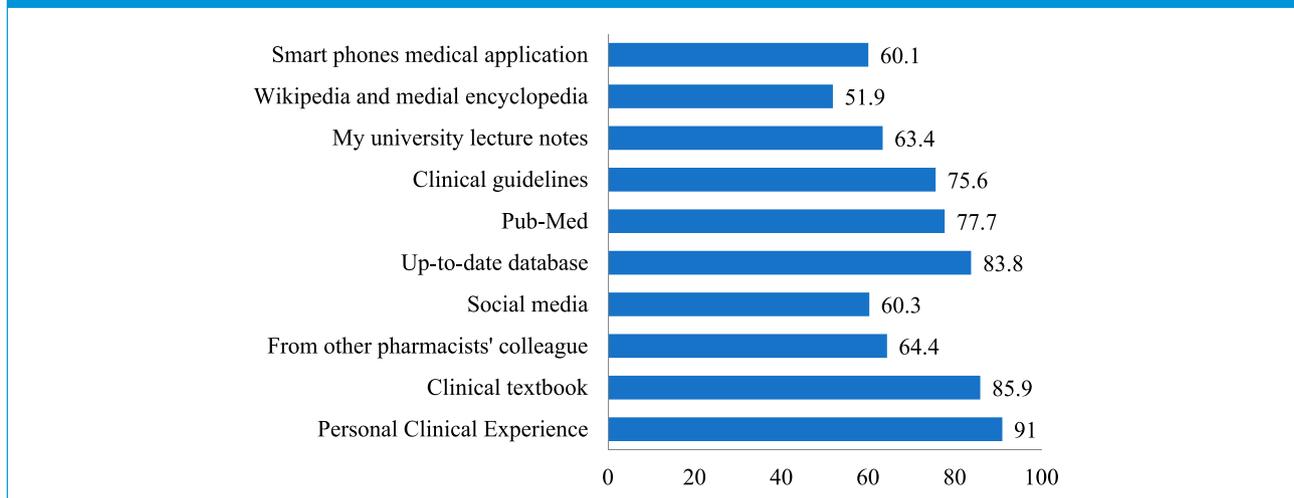
Table 1. Demographic characteristics of the study sample (N = 489).

| Demographic | Median (IQR) | n (%) |
|---|--------------|------------|
| Age (years) | 32.6 (7.5) | |
| Gender | | |
| • Female | | 130 (26.6) |
| • Male | | 359 (73.4) |
| Educational level | | |
| • BPharm/pharmD | | 415 (84.8) |
| • Clinical Master of Pharmacy | | 30 (6.1) |
| • PhD | | 44 (9.1) |
| Community practice experience (years) | 7.6 (5.2) | |
| Site of work | | |
| • Independent community pharmacy ^a | | 340 (69.5) |
| • Chain community pharmacy ^b | | 149 (30.5) |
| Place of residence | | |
| • Urban | | 310 (63.3) |
| • Non-urban | | 179 (36.7) |
| Have you ever attended a course/workshop on AMS programmes? | | |
| • Yes | | 139 (28.5) |
| • No | | 350 (71.5) |

^aIndependent community pharmacy is a single store with a sole proprietor or may consist of several stores owned by an individual or small group.

^bChain community pharmacy is an organization or individual set-up/open more than four medical stores or pharmacies.

Figure 2. Community pharmacist's main source of knowledge about antimicrobial and antimicrobial use during their practice (n = 489).



universal agreement on its educational value. These findings reflect a substantive “inflation”—a marked increase—in the population’s awareness and competence regarding AMS, indicative of the initiative’s profound impact.

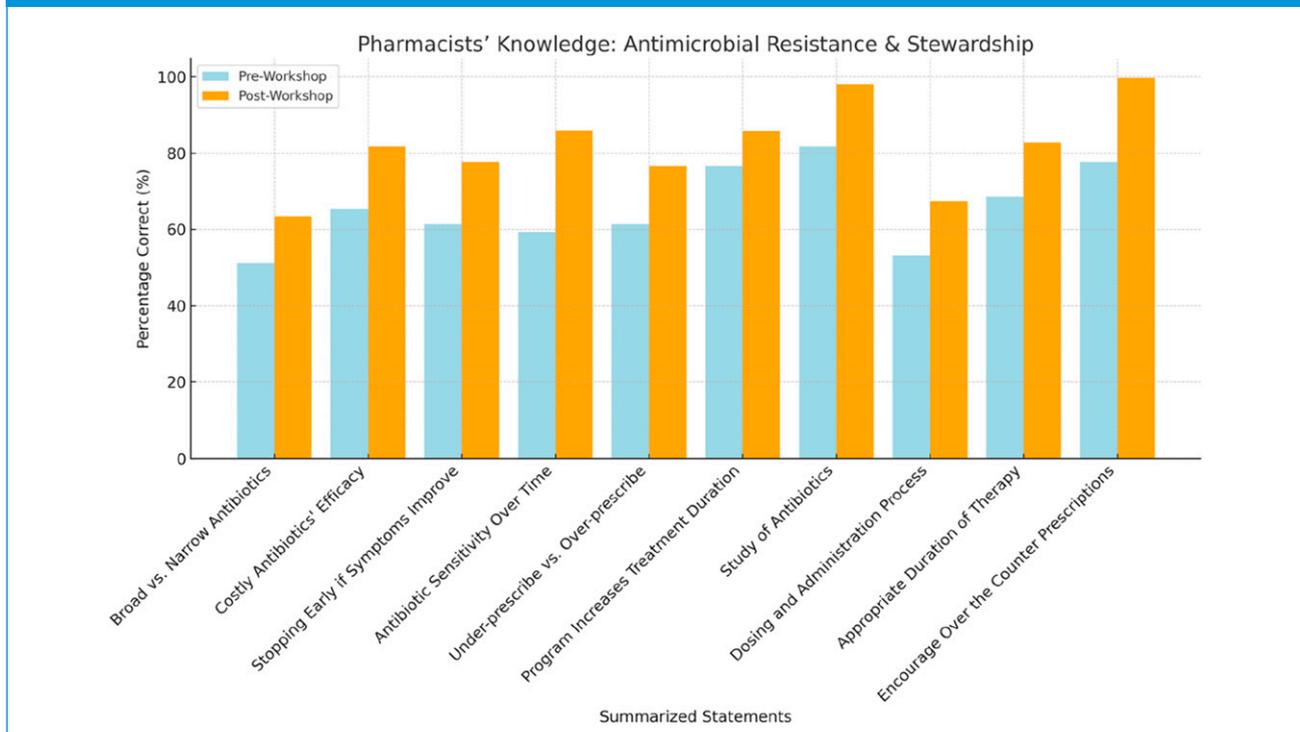
Satisfaction with the AMS workshop

As an additional part of the post-workshop questionnaire, each participant rated their level of satisfaction with the

workshop based on eight statements (Table 4; Figure 6). Participants reported gaining a deeper understanding of the principles of antimicrobial stewardship through the workshop. (n = 487, 99.6%) and that they learned new information (n = 484, 98.9%) about antimicrobial resistance (n = 480, 98.1%). Overwhelmingly, participants in the educational session agreed or strongly agreed that the knowledge gained about the significance of stewardship programs is anticipated to influence

Table 2. Community pharmacists' knowledge about antimicrobial resistance and AMS (N = 489).

| Statements | Most appropriate n (%) pre-workshop | Most appropriate n (%) post-workshop | p-Value ^a |
|--|-------------------------------------|--------------------------------------|----------------------|
| Broad-spectrum antibiotics should always be used in place of narrow-spectrum antibiotics to reduce resistance ^b | 250 (51.1) | 310 (63.3) | 0.001 ^c |
| The efficacy of the more expensive antibiotic is associated with better efficacy and lower resistance ^b | 320 (65.4) | 400 (81.7) | 0.001 ^c |
| If symptoms improve before the full course of antimicrobial is completed, your patient can stop taking it ^b | 300 (61.3) | 380 (77.7) | 0.005 |
| Antibiotic with resistance problem can become sensitive over time ^b | 290 (59.3) | 420 (85.9) | 0.002 |
| It is always better to under-prescribe antibiotics than over-prescribe ^b | 300 (61.3) | 375 (76.6) | 0.002 |
| AMS is a program that increases the treatment duration to ensure therapeutic efficacy ^b | 375 (76.6) | 420 (85.8) | <0.001 ^c |
| AMS is a study of antibiotics ^d | 400 (81.7) | 480 (98.1) | 0.015 |
| AMS is a process that involves a suitable antibiotics dosing and route of administration ^d | 260 (53.1) | 330 (67.4) | 0.016 |
| AMS is a process that involves the appropriate duration of antibiotics therapy ^d | 335 (68.5) | 405 (82.8) | 0.019 ^c |
| The role of AMS is to encourage over-the-counter prescription of antibiotics agents ^b | 380 (77.7) | 488 (99.7) | 0.043 |
| Knowledge score (out of 10), median (IQR) | 5 (3) | 8 (6) | 0.003 ^{c,e} |

^aMcNemar's test.^bFalse.^cSignificant at 0.05 significant level.^dTrue.^eUsing Wilcoxon signed-rank test.**Figure 3.** Community pharmacists knowledge towards antimicrobial resistance.

participants’ daily professional practices. ($n = 488$, 99.7%).

Discussion

The global escalation in mortality and morbidity due to communicable and infectious diseases is a pressing concern, with notable increases observed in various countries (Rochford et al., 2018). Malaysia, in particular, grapples with challenges linked to the accessibility of antibiotics and the absence of AMS protocols in community settings. The World Health Organization has emphasized the importance of training health workers in antimicrobial resistance (AMR) through its curricula guide (World Health Organization, 2019a). Additionally, several studies have underscored the urgency of augmenting AMS awareness in such environments (Akpan et al., 2020; Majumder et al., 2020; Nathwani et al., 2019; Saha et al., 2021). In 2014, Malaysia made a significant step by adopting the Protocol on AMS Program in Healthcare Facilities, thereby formalizing AMS in its healthcare system. This protocol delineates the

objectives of an AMS team and the roles of its members, emphasizing the pivotal role of pharmacists (Lai et al., 2022). Despite this formal adoption, the practical implementation of these principles in Malaysia remains limited. Our study is pioneering in evaluating the effectiveness of a community-based AMS intervention in Malaysia.

The results of our study are promising, indicating that community-based AMS interventions can indeed be effective. There was a significant enhancement in AMS knowledge and attitudes post-intervention. The participants showed a considerable improvement in selecting the most appropriate antibiotic therapy for various community pharmacy scenarios ($p = .05$). The initial knowledge about AMS was relatively low, with only a third of participants being familiar with the concept before the intervention. This lack of awareness is consistent with findings in countries like Egypt and Ethiopia, where less than half of medical practitioners were acquainted with AMS (Saleh et al., 2021). However, countries like South Africa and Australia have reported higher awareness levels (Bishop et al., 2018). The limited exposure of Malaysian community pharmacists to AMS and AMR education is a contributing factor to this knowledge gap. Interestingly, participants in our study, despite their limited awareness of AMS, demonstrated substantial baseline knowledge of AMR, paralleling findings from similar research in Egypt and Ethiopia (Tahoon et al., 2020).

Participants exhibited a positive perception of AMS both before and after the intervention. This aligns with the findings of Satterfield et al. (2020), which indicated a moderate understanding of AMS’s role among participants prior to an educational program (Satterfield et al., 2020). However, there was a notable deficiency in knowledge regarding the pharmacist’s active role in AMS. The educational workshop conducted in our study proved effective in enhancing understanding of both empirical and directed

Figure 4. Selection of correct empirical therapy pre- and post-workshop for simulated cases.

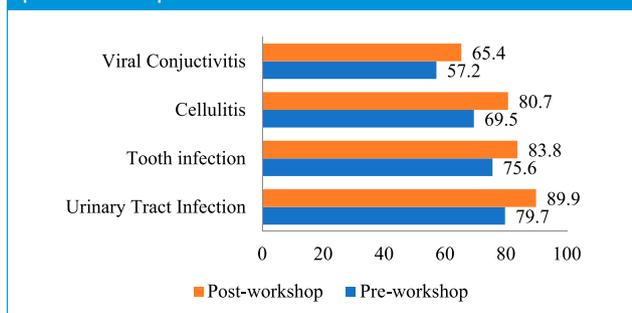
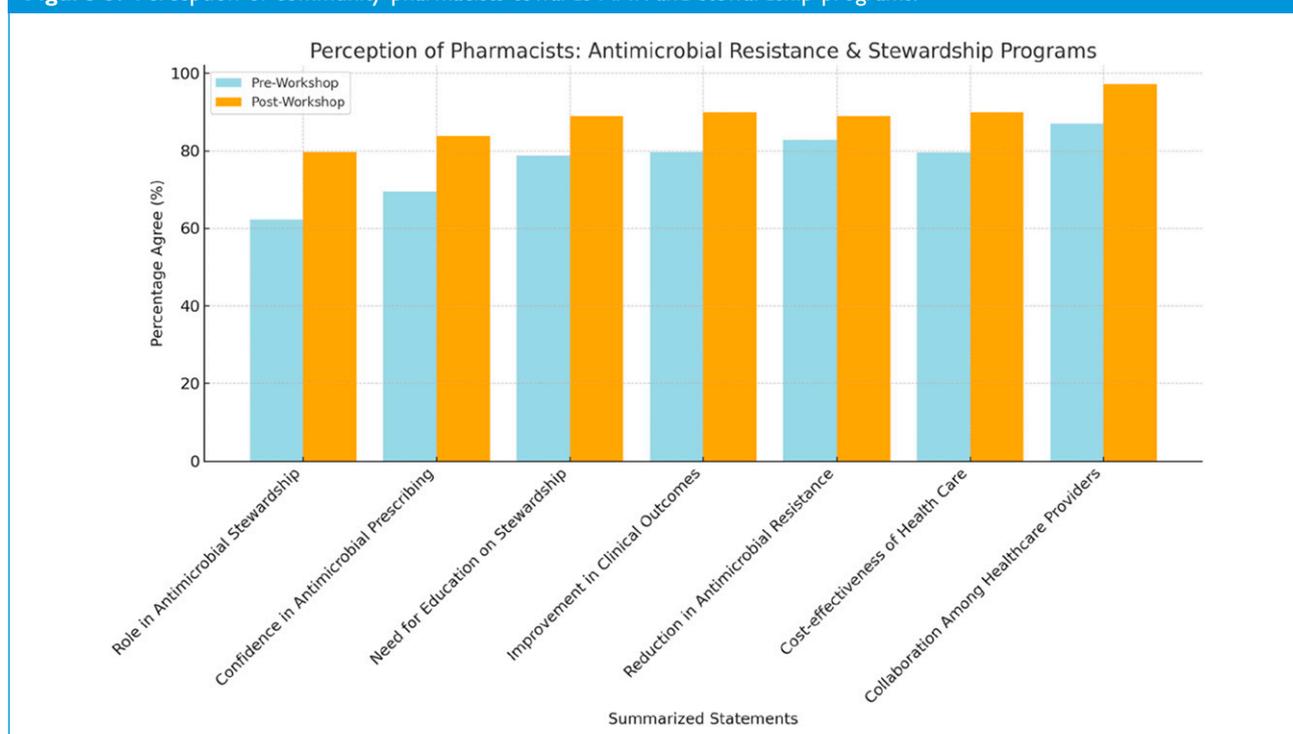


Table 3. Perception of community pharmacists towards antimicrobial resistance and the importance of AMS programs (N = 489).

| Statements | Pre-workshop | Post-workshop | p-Value ^a |
|--|----------------------------|---------------|----------------------|
| | Strongly Agree/Agree n (%) | n (%) | |
| Community pharmacists have a responsibility to take a prominent role in AMS and infection prevention | 305 (62.3) | 390 (79.7) | 0.019 |
| I feel confident about my knowledge and practice in the area of antimicrobial prescribing | 340 (69.5) | 410 (83.8) | 0.014 |
| Sufficient education on AMS should be given to community pharmacists | 385 (78.7) | 435 (88.9) | 0.045 |
| AMS will improve the patient’s clinical outcomes | 390 (79.7) | 440 (89.9) | 0.007 |
| AMS will reduce antimicrobial resistance | 405 (82.8) | 435 (88.9) | 0.003 |
| AMS improves the cost-effectiveness of healthcare sectors | 389 (79.5) | 440 (89.9) | 0.035 |
| AMS improves the collaboration between healthcare providers | 425 (86.9) | 475 (97.1) | 0.019 |

^aMcNemar’s test.

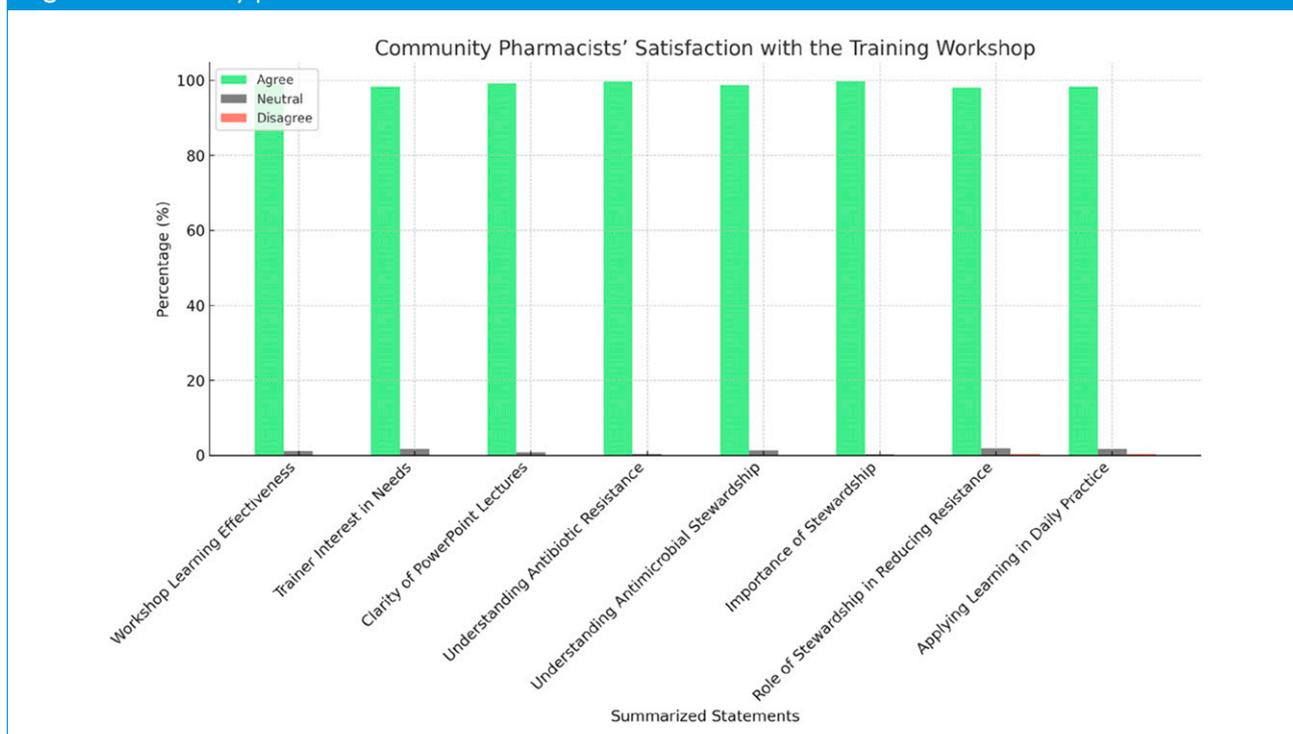
Figure 5. Perception of community pharmacists towards AMR and stewardship programs.**Table 4.** Community pharmacists' satisfaction with the training workshop (N = 489).

| Statements | Strongly Agree/ Agree n (%) | Neutral n (%) | Strongly Disagree/ Disagree n (%) |
|---|--------------------------------|------------------|--------------------------------------|
| The online workshop helped me to learn | 484 (98.9) | 5 (1.1) | 0 (0.0) |
| Trainers showed an interest in my needs during this workshop | 481 (98.3) | 8 (1.7) | 0 (0.0) |
| The PowerPoint lectures were easy to follow and understand | 485 (99.1) | 4 (0.8) | 0 (0.0) |
| The workshop made me understand the concept of antibiotic resistance | 487 (99.6) | 2 (0.4) | 0 (0.0) |
| The workshop made me understand the concept of AMS | 483 (98.7) | 6 (1.3) | 0 (0.0) |
| The educational workshop helps me understand the importance of antimicrobial stewardship | 488 (99.7) | 1 (0.3) | 0 (0.0) |
| The cases integrated into the workshop gave me clear examples of the role of AMS in reducing antimicrobial resistance | 480 (98.1) | 7 (1.89) | 2 (0.4) |
| The educational workshop will allow me to practice what I had learned in my daily practice at my practice site | 481 (98.3) | 6 (1.69) | 2 (0.4) |

therapy, which are key aspects of WHO's AMS principles (Falcone et al., 2019; World Health Organization, 2019b). The high participation rate and positive feedback from Malaysian pharmacists reflect a strong inclination towards improving practices in this area. The majority found the workshop exceedingly beneficial, underscoring the value of tailoring programs to suit the specific expertise and practice needs of pharmacists (May et al., 2021).

Our study boasts a significant strength in its large sample size and high response rate (92.6%), ensuring comprehensive representation of community pharmacies across Malaysia. This widespread participation enhances the potential for widespread dissemination of AMS principles throughout the country. While the workshop was conducted in English, which is the predominant language of practice among Malaysian pharmacists, it inadvertently excluded non-

Figure 6. Community pharmacist’s satisfaction with the educational intervention.



English-speaking individuals. The voluntary nature of the workshop may have also introduced a selection bias, attracting pharmacists who are more proactive in seeking knowledge and improvement. Ongoing research is directed at evaluating the long-term impact of this intervention on everyday practices.

Importance of the study

Our study significantly improved the knowledge of community pharmacists in Malaysia about how to use antibiotics most appropriately. This improvement could lead to better choices in dispensing medicines and help reduce the misuse of antibiotics. Over time, the study could have a big impact on public health in Malaysia, especially in fighting the problem of bacteria becoming resistant to antibiotics. By showing how useful these educational workshops are, our study supports the idea of having more training programs like this. These changes can lead to healthier patients, lower medical costs, and a change in how people think about using antibiotics. The study not only helps pharmacists but can also guide future training for other healthcare workers. In the end, our study is an important step in reducing the problems caused by the misuse of

antibiotics in Malaysia, highlighting the need for ongoing education and awareness in healthcare. To extend and sustain the educational achievements of our AMS workshop, we propose several strategies. Firstly, the incorporation of ongoing training sessions, possibly semi-annually or annually, would reinforce the core concepts of AMS and introduce new developments in the field. Additionally, integrating AMS topics into continuous professional development programs for pharmacists can ensure a steady engagement with the subject. Furthermore, leveraging digital platforms for e-learning modules can provide flexible and accessible learning opportunities. These initiatives are crucial for maintaining momentum and ensuring that the knowledge and practices imparted during the initial workshop are not only retained but also evolved in line with the latest in antimicrobial stewardship. As a recommendation for future study, the finding that 20% of workshop participants did not recognize their role in AMS warrants further exploration. Understanding the underlying reasons for this perspective is crucial for devising targeted interventions. This could be approached through qualitative methods like follow-up interviews or focused group discussions to delve into the pharmacists’ reservations or misconceptions about their role

in AMS. Subsequently, tailored strategies, such as awareness campaigns emphasizing the critical role pharmacists play in AMS, sharing success stories and best practices from peers, and providing specific resources and support for AMS implementation, could be developed. These efforts aim to cultivate a more uniform and comprehensive understanding of the pivotal role community pharmacists play in antimicrobial stewardship, ultimately fostering a more engaged and proactive approach across the profession.

Conclusion

The AMS educational workshop conducted in Malaysia was notably successful, effectively increasing AMS knowledge among community pharmacists. The findings underscore the need for more targeted AMS interventions in Malaysia, aimed at designing official AMS programs at the community level. Such initiatives are crucial for raising awareness, optimizing antibiotic use, and, most importantly, facilitating tangible changes in daily practice.

Author contributions

A.H.M started the research idea and designed the study; B.A.R.H, A.B, and J.D carried out the data collection and workshop organization. A.H.M, A.B, and J.D conducted and analyzed data. A.H.M, A.B, and J.D drafted the manuscript. A.L, D.S.R, A.A, and H.S.H reviewed and proofread the drafted manuscript. All authors state that they had complete access to the study data and approved the submission of the present version of the manuscript and take full responsibility for the manuscript.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Ethical statement

Ethical approval

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research study participants were approved by the Institutional Research Ethics Committee of Monash University Malaysia and ethical approval for this study was also obtained (REC-27-2022).

Informed consent

Informed consent was obtained from all individual participants in the study. Participants signed informed consent regarding publishing their de-identified data.

ORCID iDs

Ali Haider Mohammed  <https://orcid.org/0000-0001-5349-4583>
Arooj Abid  <https://orcid.org/0000-0001-8154-5915>

Data availability statement

Data and other materials are available upon request from the corresponding authors.

References

- Akpan MR, Isemin NU, Udoh AE, et al. (2020) Implementation of AMS programmes in African countries: a systematic literature review. *Journal of global antimicrobial resistance* 22: 317–324.
- Association GAotWM (2014) World medical association declaration of Helsinki: ethical principles for medical research involving human subjects. *Journal of the American College of Dentists* 81(3): 14–18.
- Bishop J, Kong DC, Schulz TR, et al. (2018) Meeting the challenge for effective AMS programs in regional, rural and remote hospitals—what can we learn from the published literature? *Rural and Remote Health* 18(2): 42–44.
- Bo ZM, Tan WK, Chong CSC, et al. (2022) Respiratory microorganisms in acute pharyngitis patients: identification, antibiotic prescription patterns and appropriateness, and antibiotic resistance in private primary care, central Malaysia. *PLoS One* 17(11): e0277802.
- Boochandani M, D'Souza AW and Dantas G (2019) Sequencing-based methods and resources to study antimicrobial resistance. *Nature Reviews Genetics* 20(6): 356–370.
- Dadgostar P (2019) Antimicrobial resistance: implications and costs. *Infection and Drug Resistance* 12: 3903–3910.
- Erku DA (2016) AMS: a cross-sectional survey assessing the perceptions and practices of community pharmacists in Ethiopia. *Interdiscip Perspect Infect Dis* 2016: 5686752.
- Falcone M, Paul M, Yahav D, et al. (2019) Antimicrobial consumption and impact of AMS programmes in long-term care facilities. *Clinical Microbiology and Infection* 25(5): 562–569.
- Getahun H, Smith I, Trivedi K, et al. (2020) Tackling antimicrobial resistance in the COVID-19 pandemic. *Bulletin of the World Health Organization* 98(7): 442–442A.
- Hofer U (2019) The cost of antimicrobial resistance. *Nature Reviews Microbiology* 17(1): 3.
- Lai WM, Islahudin FH, Ambaras Khan R, et al. (2022) Pharmacists' perspectives of their roles in AMS: a qualitative study among hospital pharmacists in Malaysia. *Antibiotics* 11(2): 219.
- Majumder MAA, Rahman S, Cohall D, et al. (2020) AMS: fighting antimicrobial resistance and protecting global public health. *Infection and Drug Resistance* 13: 4713–4738.
- May L, Quirós AM, Ten Oever J, et al. (2021) AMS in the emergency department: Characteristics and evidence for effectiveness of interventions. *Clinical Microbiology and Infection* 27(2): 204–209.
- Morrison L and Zembower TR (2020) Antimicrobial resistance. *Gastrointestinal Endoscopy Clinics* 30(4): 619–635.
- Nathwani D, Varghese D, Stephens J, et al. (2019) Value of hospital AMS programs [ASPs]: a systematic review. *Antimicrobial Resistance and Infection Control* 8(1): 1–13.
- Rochford C, Sridhar D, Woods N, et al. (2018) Global governance of antimicrobial resistance. *The Lancet* 391(10134): 1976–1978.
- Saha SK, Barton C, Promite S, et al. (2019) Knowledge, perceptions and practices of community pharmacists towards AMS: a systematic scoping review. *Antibiotics* 8(4): 263.

- Saha SK, Kong DC, Thursky K, et al. (2021) AMS by Australian community pharmacists: uptake, collaboration, challenges, and needs. *Journal of the American Pharmacists Association* 61(2): 158–168.e7.
- Saleh D, Abu Farha R and Alefishat E (2021) Impact of educational intervention to promote Jordanian community pharmacists' knowledge and perception towards AMS: pre-post interventional study. *Infection and Drug Resistance* 14: 3019–3027.
- Sarwar MR, Saqib A, Iftikhar S, et al. (2018) Knowledge of community pharmacists about antibiotics, and their perceptions and practices regarding AMS: a cross-sectional study in Punjab, Pakistan. *Infection and Drug Resistance* 11: 133–145.
- Satterfield J, Miesner A and Percival K (2020) The role of education in AMS. *Journal of Hospital Infection* 105(2): 130–141.
- Stewardship WA (2020) A competency-based approach. *World Health Organization Website*. Available at: <https://openwho.org/courses/AMR-competency> [Accessed: Date of Access].
- Tahoon MA, Khalil MM, Hammad E, et al. (2020) The effect of educational intervention on healthcare providers' knowledge, attitude, & practice towards AMS program at National Liver Institute, Egypt. *Egyptian Liver Journal* 10(1): 1–7.
- World Health Organization (2019a) *AMS Programmes in Health-Care Facilities in Low-And Middle-Income Countries: A WHO Practical Toolkit*. Geneva: World Health Organization.
- World Health Organization (2019b) *Health Workers' Education and Training on Antimicrobial Resistance: Curricula Guide*. Geneva: World Health Organization.