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A Review on the Role of Community Pharmacists on Antimicrobial Stewardship Programs

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Abstract

Antibiotics are the "marvel medicines" for fighting bacteria. For the past years, multiple varieties of antibiotics have performed well in combating microbes. However, over time, bacteria have developed a way to counter antimicrobial agents' effects and become resistant to antibiotics. The goal of this paper was to conduct a systematic review of published studies on the role of community pharmacists, as drug experts, in antimicrobial stewardship programs (ASPs). Thus, a search strategy was employed to gather existing literature using the following databases: Elsevier, Google Scholar, PubMed, and ScienceDirect. The literature retrieved was classified and analyzed according to the perception, knowledge, and practices toward AMS programs. After evaluation, results show that pharmacists are essential when creating and implementing ASPs in inpatient and outpatient settings. They can monitor and report AMS indicators and ensure all legal specifications are followed for accreditation and payment reasons. Most pharmacists always/often dispense antimicrobials with a prescription, evaluate the prescribed antimicrobials if they follow the guidelines, and communicate with prescribers whenever they have difficulty reading the prescription. Additionally, approximately 85% of pharmacists agreed that to enhance the understanding of antimicrobial stewardship, pharmacists should be exposed to relevant workshops and conferences and that "antimicrobial stewardship programs reduce the problem of antimicrobial resistance." However, the results indicate that appropriate actions are still needed to rationalize antimicrobial use in the future and that more training and access to AMS guidelines are necessary.

1. Introduction

Antimicrobial resistance is one of the most severe threats to public health that plagues the world this century [1]. According to the Center for Disease Control and Prevention (CDC), 2 million Americans had serious infections with resistant bacteria in 2013, and 23,000 people died directly from diseases brought on by resistant bacteria [2]. Implementing Antimicrobial Stewardship (AMS) is one of the crucial measures that can efficiently reduce antimicrobial resistance and control the usage of antibiotics [2]. AMS is the optimal selection, dosage, and duration of antimicrobial agents or treatments that would result in the best clinical outcomes, with minimal toxicity to the patient and minimal effect on subsequent resistance [3]. Antimicrobial stewardship also refers to a variety of quality improvement activities focused on the treatment and/or prevention of infectious diseases through tincreasing and sustaining the appropriate use of antimicrobials [4].

The American Society of Health-System Pharmacists (ASHP) believes pharmacy professionals should play a major role in healthcare systems' infection prevention and control and antimicrobial stewardship initiatives [5]. Since community pharmacists are among the most accessible healthcare providers, they can significantly minimize antibiotic resistance [6]. Apart from their role in the community pharmacy setting, they also make an effort to prevent and reduce microbial infections within the community by educating their patients, communicating with the prescribers, and evaluating the appropriateness of their prescribed antibiotics [7]. With that, this review aims to address the critical role of community pharmacists in fighting antimicrobial resistance through antimicrobial stewardship programs.

2. Methodology

2.1. Search Strategy

This review was conducted using journal databases such as Elsevier, Google Scholar, Springer, PubMed, MDPI, and ScienceDirect. The search was confined to research articles and studies from 2012 to the present using specific criteria as follows: (1) antimicrobial stewardship, (2) antimicrobial stewardship program, (3) perspective of community pharmacists in AMS programs, (4) knowledge of community pharmacists in AMS programs, and lastly, (4) practice of community pharmacists in AMS program. Seven investigators conducted the searches independently (Shannen Tiffany Ambray, Yala Hope De Real, Ira Grant Diaz, Emerald Sheen Panaguiton, Walid Radzak, Cesar Armand Reyes, Eunice Sablay) who retrieved different studies published from 2012 to the present. There were no online procedures for this review article.

2.2 Study Selection

The inclusion criteria for this review are articles on antimicrobial stewardship programs, articles on the perspective of community pharmacists in Antimicrobial Stewardship Programs, articles on the knowledge of community pharmacists in Antimicrobial Stewardship Programs, and lastly, articles on the practices of community pharmacists in Antimicrobial Stewardship Programs. The investigators carefully examined the full articles that were cited and confirmed that they fulfilled the criteria.

3. Results and Discussion

3.1 Literature Search

The literature search yielded 41 articles that were utilized and screened for a full-text assessment.

Table 1. Antimicrobial Stewardship Program

Author and Year	**Method**	**Result**
Malani et al., 2013	An ASP team was formed and assigned to prospectively assess eight target antimicrobials for start and weekly use. Using the collective administrative data and data will be compared to similar data from an earlier date before the program's implementation.	Overall, the assessment revealed that a large portion of antimicrobial orders are appropriate, and only a few were rejected. Roughly 50% decreased the risk of Clostridium difficile infection (CDI) [8].
Yam et al., 2012	A multidisciplinary team was established to implement a stewardship program aimed at six antimicrobials with a high potential for misuse as a result of a gap analysis of AMS services at a rural hospital where physician specialists in infectious diseases (ID) or pharmacists with advanced ID training were not available. The involvement of a remotely situated ID physician specialist in the program's weekly case review teleconferences was a crucial component.	The control of antimicrobial release increased exponentially in the first 13 months. Pharmacist-initiated AMS interventions increased dramatically after program implementation, from a baseline average of 2.1 interventions per week to an average of 6.8 interventions per week. Though it also showed an increase in physician reviews by the AMS team and better collaboration [9].
Nowak et al., 2012	Before and following the introduction of the ASP, which involved daily physician assessment of summary reports on all adult inpatients receiving antibiotic therapy, the investigators assessed clinical outcomes and cost metrics. Secondary outcome outcomes included patient survival and length of stay (LOS) in instances containing the indicator diagnoses of pneumonia and abdominal sepsis. The primary outcome measures were annual antimicrobial expenditures and rates of infections attributable to common nosocomial bacteria.	Antimicrobial spending was reduced in the program's first year and remained largely consistent in subsequent years. Antimicrobial spending had climbed by an average of 14.4% annually in the years before ASP implementation. Following the adoption of the ASP, there was a decline in the incidence of nosocomial infections caused by Clostridium difficile, methicillin-resistant Staphylococcus aureus, and vancomycin-resistant enterococci [10].
Leuthner, Doern 2013	The ideal oversight committee for a hospital-based antimicrobial stewardship program comprises three people: a clinical pharmacologist with a Pharm.D. A board-certified infectious disease physician, a board-certified doctorate-level director of the clinical microbiology laboratory, and two years of fellowship training in infectious	The frequency with which the antimicrobial stewardship team's therapeutic recommendations are followed and in cases where therapeutic adjustments are made, how long it takes before a suggestion is made before the change is really implemented are crucial metrics to track. Using historical data as a frame of reference, additional factors to

	diseases, preferably acquired through a training program approved by the American College of Clinical Pharmacy, are also required. The clinical pharmacologist is anticipated to give the program all of their attention. The infectious disease doctor and clinical microbiology laboratory director would put some of their time into the program; the precise amount of time would depend on the program's size, complexity, and breadth. These staffing needs could differ depending on the size of the facility and the type of patients being treated there.	be taken into account include mortality rates, most particularly mortality attributable to infection, overall length of hospitalization, time spent in particular care areas like the medical and surgical ICUs, rates of recurrent infection, frequency of particular laboratory studies, antibiotic usage patterns, and institutional antimicrobial resistance patterns. In addition to serving as the foundation for presentations at medical-scientific gatherings and publications in peer-reviewed journals, systematic collection and objective analysis of such data can be crucial in helping institutions justify antimicrobial stewardship programs [11].
Hersh et al., 2015	In a set of 31 freestanding children's hospitals (9 ASP+, 22 ASP), we assessed the effect of ASPs on antibiotic prescribing over time as defined by days of therapy/1000 patient-days. From 2004 to 2012, we examined the average antibiotic use for all ASP+ and ASP hospitals before and after the 2007 Infectious Diseases Society of America guidelines for developing ASPs were published. Both the overall antibacterial drug class and a particular subset's antibiotic use were compared (vancomycin, carbapenems, linezolid). We used interrupted time series through dynamic regression to identify variations between the average monthly changes in antibiotic use before and after the program was launched for each ASP+ facility.	Between 2007 and 2012, the years after the publication of Infectious Diseases Society of America guidelines, there was an overall decrease in average antibiotic use in ASP+ hospitals that was greater than in ASP hospitals. With an average monthly fall in days of therapy/1000 patient-days of 5.7%, 8 of 9 ASP+ hospitals showed reductions in antibiotic use when compared to pre-implementation trends. The average monthly decline for the chosen subset of antibiotics was 8.2% [12].
Akpan et al., 2015	For papers published between 1990 and March 2019, we searched five electronic databases, including PubMed, Scopus, Cochrane library, African Journal Online, CINAHL, and Google Scholar. We combined the names of the nations in Africa's five regions with terms related to antimicrobial stewardship. Studies using any stewardship techniques and of any design were included. The National Heart, Lung and Blood Institute (NHLBI) quality evaluation method for before and after studies was used to evaluate the caliber of the included studies.	13 studies out of 1752 identified titles met the requirements for inclusion. One each in Sudan, Tanzania, and Egypt, along with three in Kenya, were the locations of seven of the studies. Eleven studies had a minimal risk of bias and were of good quality. The majority of the included studies used process measures to evaluate the outcomes, and they were linked to increased adherence to antibiotic guidelines, proper prescribing, decreased antibiotic use, and cost savings. According to two studies, there has been a decrease in the incidence of surgical site infections, a non-significant change in mortality, and a 30-day readmission rate [13].

Antimicrobial Resistance (AMR) is a condition in which bacteria, viruses, fungi, and parasites evolve over time and cease to respond to antibiotics, making infections more difficult to cure and raising the risk of disease transmission, life-threatening sickness, and death. Drug resistance makes it harder or impossible to treat illnesses and renders antibiotics and other antimicrobial medications useless [14].

To address antimicrobial resistance, antimicrobial stewardship programs encourage the prudent use of antibiotics. The implementation of ASPs that pharmacists spearhead revealed that there has been a significant decrease in the average use of antimicrobials for the following reasons: (1) proper assessment of antibiotic orders, wherein some 12% of the orders were denied, leading to 50% reduction in the risk of developing Clostridium difficile infection (CDI) [8]; (2) physicians requested for case reviews by the pharmacist-initiated ASP team owing to a decrease in annual antibiotic cost and

decreased CDI from an average of 5.5 cases per 10,000 patients to 1.6 cases per 10,000 patients per day, including other cases of infections such as methicillin-resistant Staphylococcus aureus (MRSA), and vancomycin-resistant enterococci (VRE) [9,10]; lastly, (3) proper prescribing of antibiotics and increased adherence due to antibiotic guidelines [13]. Thereby, it can be concluded that antimicrobial use is well-regulated with the knowledge and skills of community pharmacists in rational drug use and drug therapy in pharmacist-initiated ASP interventions.

However, it is important to note that an economic value evaluation is necessary to create, adopt, and execute ASPs. Only a few studies show how beneficial AMS programs are financially [15]. Furthermore, institutions with ASPs must properly define the program's objectives and must constantly make an effort to improve and be active in the implementation of ASPs for it to be effective. Cost analyses are also important and must be used when and where necessary [12][13].

Table 2. Perception of Community Pharmacists in Antimicrobial Stewardship Programs

Author and Year	**Method**	**Result**
Parente, Morton 2018	Prospective audit with intervention and feedback (PAIF)	When creating and implementing Antimicrobial stewardship programs in inpatient and outpatient settings, pharmacists are essential. Pharmacists can optimize the antimicrobial selection, dose, and duration through routine reviews of antibiotic regimens as part of PAIF. Additionally, pharmacists can monitor and report AMS indicators and ensure all legal specifications are followed for accreditation and payment reasons. Pharmacists are crucial in managing ID patients as long as antibiotic resistance persists [16].
Chan *et al.*, 2022	A cross-sectional survey was disseminated to pharmacists worldwide via the Commonwealth Pharmacists' Association and related networks. Data were collected on demographics, antibiotic supply practices, and knowledge and beliefs about AMR.	Knowledge about antibiotics and beliefs about AMR were positively correlated. The odds of supplying antibiotics without a prescription were 7.4 times higher among respondents from lower-income countries [adjusted odds ratio (AOR) = 7.42, 95% CI 4.16-13.24]. Conversely, more positive AMR beliefs were associated with lower odds of supplying antibiotics without a prescription (AOR = 0.91, 95% CI 0.86-0.95) [17].
Wu *et al.*, 2021	A systematic review was conducted to characterize the existing literature on community pharmacists prescribing systemic antimicrobials. MEDLINE, EMBASE, and International Abstracts for English-language articles published between 1999 and June 20, 2019, as well as hand-search reference lists of included articles and incorporated expert suggestions were used.	Pharmacists often prescribe uncomplicated urinary tract infection (UTI), acute pharyngitis, and cold sores using independent and supplementary prescribing models. This was associated with high rates of clinical improvement (4 studies), low rates of retreatment and adverse effects (3 studies), and decreased healthcare utilization (7 studies). Patients were highly satisfied (8 studies) and accessed care sooner or more easily (7 studies). Pharmacist intervention reduced unnecessary prescribing for acute pharyngitis (2 studies) and increased the appropriateness of prescribing for UTI (3 studies) [18].

Koodae*t al*., 2022	Systematic review and meta-analysis following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines were conducted.	In total, 24 studies (9,984 patients) were included in the qualitative synthesis, and 22 studies (5,791 patients) had data for the primary outcome and were included for the quantitative assessment (meta-analysis). Appropriate prescribing of antibiotics was more likely with pharmacist intervention (22 studies; odds ratio [OR], 3.47; 95% confidence interval [CI] 2.39 to 5.03), particularly among patients with pneumonia (5 studies; OR, 3.74; 95% CI 2.14 to 6.54) or urinary tract infection (4 studies; OR, 1.76; 95% CI 1.24 to 2.50) [19].
Monmaturapoj*et al*., 2021	Standard systematic review methods were used. The search strategies and databases used in a previous Cochrane review were applied. Studies that reported pharmacist-led AMS interventions were included. A narrative synthesis was used to report the findings. PRISMA guidelines were followed.	From 6971 records retrieved and screened, 52 full-text articles were included. Most studies were undertaken in teaching hospitals (N = 45), and many were conducted in North America (N = 27). Most interventions targeted junior or ward physicians and lasted between one and six months. All studies evaluated educational interventions often in combination with other interventions and reported improvements 'in compliance with target AMS practice'. Greater compliance was achieved with multiple interventions. Pharmacist-led interventions reduced the duration of antimicrobial therapy without increasing mortality [20].
Ourghanlian*et al*., 2019	A retrospective observational multicenter study that includes hospital pharmacists from the French Antibiotic Consumption Surveillance Network (ATB-Raisin) was conducted.	It showed that pharmacists were the antibiotic advisor in a substantial proportion of hospitals (25%) and that this was associated with a lower antibiotic consumption (–20%); this could be related to greater versatility of pharmacists than ID specialists, who usually focus on more complex situations. Greater efforts can be quantitatively made on antibiotic consumption for the most simple and classic situations (non-severe infection and non-resistant bacteria). This study also showed that pharmaceutical review is a useful tool to limit antibiotic use (–18%), especially if it covers all hospital beds [21].
Wong *et al*., 2021	Focus group discussions (FGDs) were conducted with non-ASP hospital pharmacists purposively sampled from 1200-bed National University Hospital (NUH), 1700-bed Tan Tock Seng Hospital (TTSH), and 1785-bed Singapore General Hospital (SGH) in Singapore between November 2018 and April 2019.	Formalizing the role of hospital pharmacists as antibiotic stewards and providing them with the required resources and training will capitalize on their untapped potential to enhance ASPs and further optimize antibiotic use in hospitals [22].
Cantudo-Cuenca *et al*., 2022	A prospective quasi-experimental study was conducted to implement an ASP in a public 194-bed hospital in Spain.	The global consumption of antimicrobials was significantly reduced from 907.1 AUD in the pre-intervention period to 693.8 AUD in the intervention period (-23.5%), with a

		significant drop in carbapenems (73.3 vs 34.9 AUD; p=0.012) and fluoroquinolones (181.9 vs. 95.8 AUD; p=0.012). Overall consumption of antibacterial agents was reduced by 23.1% (874.6 vs. 672.5 AUD; p=0.012) [23].
Magedanz*et al*., 2012	A quasi-experimental study regarding antibiotic consumption was conducted at Instituto de Cardologia.	Based on the findings, pharmacists could help prescribe antibiotics more judiciously, reducing costs and altering the trend of bacterial resistance [24].
Fay *et al*., 2019	A retrospective quasi-experimental study was conducted evaluating UC patients with positive urine or wound cultures following discharge.	Total guideline-concordant prescribing for all diagnoses was significantly improved in the post-ASP group (pre-ASP, 41.3% versus post-ASP 53.3%, p = 0.037). Additionally, guideline-concordant antibiotic selection improved in the post-ASP group (pre-ASP, 51% versus post-ASP, 68%, p = 0.01). There were no differences in UC, and ED revisits within 72 hours (p = 1.0) or hospital admissions within 30 days (p = 0.723) [25].
Rusic *et al*., 2021	The physician's questionnaire consisted of 47 items, and the pharmacists' questionnaire consisted of 50 items.	The result shows that as many as 76 (42.0%) physicians would prescribe an antimicrobial when unsure whether the infection was of viral or bacterial etiology. More than half of the participants considered family medicine doctors the greatest contributors to AMR (N = 216, 59.8%), followed by patients (N = 175, 48.5%).When dispensing and prescribing an antibiotic, more consideration should be paid to patient consultation since this may lessen their role in AMR [26].

At present, the threat posed by the emergence of antimicrobial resistance across all parts of the globe is still a prevailing concern among healthcare communities and societies. One of the greatest contributors to AMR was stated to be family medicine doctors since they tend to prescribe antimicrobial medications if they are uncertain of an infection's origin [26]. As a response, antimicrobial stewardship programs are being implemented to slow down the development of this issue. For the execution of such programs, the focus is directed at pharmacists due to their innate knowledge of both antimicrobial medications and antimicrobial resistance. Pharmacists will play a crucial role in managing patients afflicted with infectious diseases as long as antimicrobial resistance continues to persist [16].

As presented in table 2, the utilization of pharmacists in the struggle against AMR is often viewed with positivity by the majority. Several improvements were noted by various studies, including reduced antimicrobial therapy duration, costs, global consumption, and increased compliance with antimicrobial stewardship programs [20][23][24]. Pharmacists act as antibiotic advisors during consultations, and all prescriptions are systematically reviewed by the pharmaceutical team [21]. The aid provided by pharmacists is also correlated with the reduction in overall global consumption of antimicrobials, thereby changing the trend of bacterial resistance [23]. Pharmacist-led interventions were reported to lessen the duration of antibiotic therapy and the costs that come with it [20][24]. Only establishing the role of pharmacists in AMS, along with supplying them with additional training and necessary resources, will enhance their potential as antibiotic stewards [22].

Table 3 Knowledge of Community Pharmacists in Antimicrobial Stewardship Programs

Author and Year	**Method**	**Result**
Iftikhar *et al*., 2018	Descriptive cross-sectional study using a self-administered and pretested questionnaire was used for the data collection. A simple random sampling method was used to select pharmacists in the community.	The participants' knowledge regarding antibiotics is good. They showed positive insights but poor practices regarding Antimicrobial Stewardship. Participants were of the view that the antimicrobial stewardship program could be beneficial for

		healthcare professionals for the improvement of patient care improvement, and 78% of participants gave their opinions regarding the incorporation of the ASP in community pharmacists [27].
Borton*et al*., 2019	Scoping review was employed using the PRISMA extension for scoping reviews and methodology framework described by Arksey and O'Malley consisting of 7 stages.	Perceived knowledge of the construct of antimicrobial stewardship was reported in terms of Community Pharmacist Familiarity or hearing of the term of Antimicrobial stewardship. Most community pharmacists were familiar with the term Antimicrobial stewardship [28].
Caijun et al., 2020	Descriptive cross-sectional study among community pharmacy staff in Northeastern China, from April 1 to May 31, 2019, using a self-administered KAP questionnaire comprising 20 items. Data analysis was carried out by employing Mann-Whitney and Kruskal-Wallis tests.	The majority of the participants demonstrated a good understanding of the use of antimicrobials, but they lacked an adequate understanding of the Antimicrobial Stewardship program [29].
Rehman *et al*., 2021	A cross-sectional study was conducted among pharmacists working in different sectors between March to June 2017.	The majority of pharmacists agreed that "antimicrobial stewardship is essential to improve patient care" and further added that training must be exerted on the use of antimicrobials as half of the participants confessed that communication with the prescriber was needed as of unsureness of the antimicrobials prescription [30].
Abdulraman*et al*., 2020	The study used a descriptive cross-sectional study. The study involved RCPs. RCPs were chosen using simple random sampling from a total of 225 RCPs. Data collection was done using a structured self-administered questionnaire. Data were were analyzed using a Statistical Package. Fisher's exact test was used to determine the relationship between categorical variables.	Majority of the Community pharmacists (93.8%) had good knowledge with regards to antibiotic resistance that was related to their work experience. Majority of Community Pharmacists (64.4% strongly agreed, 29.2% agreed) that antibiotics resistance is a public health problem. Pharmacists' knowledge about antibiotic resistance is attributed to the adequate knowledge of antibiotics that they acquire during their university training and practice [31].
Ali *et al*., 2018	Cross-sectional Study was used among pharmacists working in different sectors, community pharmacists in an urban setting, and with different job descriptions (hospital and community pharmacy). A validated questionnaire was used. Data were analyzed using SPSS. Descriptive analysis was used to express data as frequencies and percentages. A Non-parametric test was used, and items were ranked based on the relative index values.	83.9 % of pharmacists agreed that antimicrobial stewardship is essential to improve patient care. 87.8% of pharmacists agreed that pharmacists should be trained on the use of antimicrobial drugs. Approximately 85% of pharmacists agreed that to enhance the understanding of antimicrobial stewardship, pharmacists should be given exposure to relevant workshops, conferences, and workshops activity and that "antimicrobial stewardship programs reduce the problem of antimicrobial resistance" [32].
Haseeb *et al*., 2022	Descriptive cross-sectional study was used to evaluate the knowledge and perception of	500 participants responded to 8 questions regarding knowledge about antimicrobials.

	CPs regarding antimicrobial stewardship programs in community pharmacy settings. A validated questionnaire was used in the study. Descriptive statistics in terms of frequencies and percentages were used.	Respondents had good knowledge of antimicrobials. 93.2% of participants strongly agreed/ agreed that antimicrobial stewardship programs improve patient care and are statistically significant, 90.3% of respondents agreed/ strongly agreed that antimicrobial stewardship programs be incorporated at the community pharmacy level, while 90.8% responded that antimicrobial stewardship programs reduce the problem of antimicrobial resistance. Most of the community pharmacists (86.5%) agreed/ strongly disagreed that adequate training should be provided to community pharmacists on antimicrobial use [33].
Hayat et al., 2019	A descriptive cross-sectional study was conducted to investigate the perception of pharmacists on community-based antimicrobial stewardship programs in three different provinces of China, specifically its capital cities as the locale between March and July of 2019. A random sampling method was utilized.	A response rate of 87.4% was collected from a total of 476 participants where 74% trust the vital role of ASPs in enhancing patient care. 34% of the participants inquired about their knowledge of antimicrobials. Participants- always (30.5%), and often (28.1%), cooperate with other healthcare professionals in their work [34].
Ballirame*t al*., 2021	A cross-sectional online questionnaire-based survey was conducted nationally among doctors, pharmacists, and nurses about their knowledge, attitudes, and practices from November 2017 to January 2018. The questionnaire comprised demographic information and KAP questions.	Doctors, pharmacists, and nurses all had prescription confidence scores of 57.82%, 32.88%, and 45.28%, respectively. 441 doctors (45.2%) expressed a lack of confidence in the use of combination therapy. Correct prescriptions were written with a level of trust from 436 doctors at 33.99%, nine pharmacists of 41.88%, and 107 nurses at 35.23%. Education programs, according to healthcare professionals (1600 [91.22%]), will help fight AMR. Only 842 HCPs (40.13%) participated in training on these subjects, and 1712 (81.60%) asked for additional information and training [35].
Khumra*et al*., 2022	Descriptive pilot study was used in the study. The study evaluated pharmacists' perceptions and coaching experiences through qualitative methods.	Ward pharmacists gave AMS coaching a positive review, saying they felt it gave them more confidence to share ideas with prescribers and helped them find a variety of suggestions to improve antimicrobial dosing. Workload problems were named as the biggest implementation roadblock. To increase the viability of coaching implementation, suggestions were given. Sixty-nine percent (113/162) of the 162 AMS suggestions for a variety of antibiotics that were found during coaching were accepted and put into practice [36].
Godman et al., 2019	Descriptive, cross-sectional study involved 137 physicians and 61 pharmacists.	Antimicrobial stewardship program knowledge was relatively low among 51% of physicians and 39% of pharmacists. 9% of physicians and pharmacists (20%)

		demonstrated sufficient knowledge of the basic principles of AMS. Physicians' and pharmacists' knowledge levels were associated with years of practice, job position or practice rank, and previous AMS training. Despite positive perceptions, basic knowledge of antimicrobial stewardship programs was relatively low. Context-specific educational interventions and capacity building are needed to address AMS gaps [37].
Hancock., 2016	Prospective and the investigational study was used and the study population was 50 community pharmacists in the Kirklees and Calderdale areas, and surrounding local areas, and 100 participating members of the public in Huddersfield town center.	The study suggests that increased awareness is necessary of the resources that are available to pharmacists regarding antibiotic resistance initiatives and monitoring of antimicrobial prescribing. In addition, an improvement is required concerning patient education by community pharmacists [38].
Angelillo et al,, 2019	A cross-sectional telephone survey using a semi-structured interview was performed between September 2018 and April 2019 among a random sample of CPs	Majority of respondents were aware that the overuse of broad-spectrum antibiotics (98.3%), patient self-medication (96.2%), failure to comply with dosage (93.1%), and non-adherence to the antibiotic course (89.8%) were causes of antibiotic resistance. Two-thirds of the participants (61.5%) correctly answered that the overuse of antibiotics in primary care, hospital settings, and veterinary medicine was a cause of antibiotic resistance [39].
Aslani et al., 2019	A cross-sectional survey was conducted among a random sample (n = 369) of community pharmacies across nine provinces in Sri Lanka using a self-administered questionnaire regarding their antibiotic knowledge and dispensing practice. Data were analyzed using descriptive and inferential statistic.	Overall mean antibiotic knowledge score was 26.1. The overall mean knowledge score $t(263) = 2.41$, $p = 0.017$, specific knowledge about antibiotic resistance $t(262) = 4.98$, $p = 0.021$, and legal aspects of antibiotic dispensing were significantly higher among pharmacists than assistants. One in every three pharmacy staff reported that they dispensed antibiotics without a prescription on patient request; however, the proportion was close to half when the patient was known to them. About 30% of the staff reported having supplied antibiotics for minor infections in the week prior to the survey. Despite the law prohibiting provision, antibiotic dispensing without a prescription continues in community pharmacies in Sri Lanka [40].

Pharmacists have a responsibility to take eminent roles in AMS and infection prevention and control programs in health systems. Most community pharmacists show familiarity with the term AMS [28][29] and good insights regarding the importance of antibiotics but they have poor practices regarding AMS. They further added that AMS is a vital point in improving the patient care that they provide [30][35]. Pharmacists should take part in antimicrobial stewardship and infection prevention and control efforts through clinical endeavors focused on antimicrobial utilization and membership on pertinent committees and multidisciplinary work groups within the health system [41].

As presented in Table 3, presenting the knowledge of community pharmacists in antimicrobial stewardship programs, the level of knowledge entirely depends on how progressed one's nation's healthcare system which helps in giving the pharmacists in the community pharmacy setting the knows and

hows regarding antimicrobial stewardship programs [29]. Nevertheless, the majority of what is presented shows significant positive results on their knowledge and acknowledges the necessity of antimicrobial stewardship programs to be implemented which aim to – promote the appropriate use of antimicrobials (including antibiotics) [32][34] and improve patient outcomes, reduces microbial resistance, and decreases the spread of infections caused by multidrug-resistant organisms [33]. The utilization of AMS resulted in a positive review as the pharmacists were more confident to provide better patient care [36] albeit, of relatively low knowledge among other medical practitioners [37]. Hence, the need for promoting and confessing the importance of antimicrobial stewardship programs for improving the general patient care [38][39][40].

Table 4. Practices of Community Pharmacists in Antimicrobial Stewardship Programs

Author(s) and Year	**Method**	**Result**
Atif *et al*., 2020	In-depth, semi-structured interviews were used to gather information from the community pharmacists in Bahawalpur, Pakistan, for a qualitative study. The technique of convenience sampling was employed to enlist study participants. The data were analyzed using a thematic analysis strategy in order to get results that were in line with the study's goals.	A total of fifteen community pharmacists were interviewed. According to the findings of the study, prescribing and dispensing practices were not followed. Only a few patients were educated about the antibiotics they were purchasing [42].
Zawahir*et al*., 2019	A cross-sectional study using simulated clients (SC) was employed to assess the appropriate dispensing practices of community pharmacies with regard to antibiotics. A total of 243 pharmacies in Sri Lanka were involved and gave their consent for the conduct of the study.	The results indicate that only a few pharmacists ask for a prescription, and recommend the clients see a doctor. More than half of the pharmacies in Sri Lanka dispense antibiotics without requiring a prescription [43].
Saleh *et al*., 2022	An online-based cross-sectional study involving community pharmacies in Jordan was conducted to assess the practice of community pharmacies toward AMS, which lasted for a period of two months. The study utilized a structured questionnaire that was distributed electronically via social media platforms.	The results showed that the majority of the pharmacists always/often dispense antimicrobials with a prescription, which contains clinical information. Additionally, pharmacists always/often evaluate the prescribed antimicrobials if they follow the guidelines. Pharmacists also always/often ask patients about the adverse effects, patient history, or any allergy to the antimicrobials, and change the prescription once allergies are established. Lastly, pharmacists also always/often communicate with prescribers whenever they have difficulty reading the prescription [44].
Saha*et al*., 2021	A nationwide survey using random sampling of community pharmacists was conducted in Australia from April to October 2019.	The results show that the respondents are familiar with AMS but still feel the need for more training and access to AMS guidelines. Moreover, most of the respondents stated that they counsel patients, while others say that they review drug interactions and possible allergies before dispensing antimicrobials. Furthermore, community pharmacists are less likely to communicate with general practitioners in the case of an antimicrobial prescription that is believed to be suboptimal due to the perceived lack of receptiveness coming from practitioners regarding antimicrobial choice and dosage [45].

Bishop *et al*., 2019	A narrative overview strategy was employed to examine antimicrobial stewardship strategies and identify the role of community pharmacists in the reduction of antimicrobial resistance.	Five community pharmacist-led interventions were identified: namely; Collaborative Practice Agreements (CPAs), point-of-care (POC) testing, patient consultations, academic detailing, and being advocates for patients and other healthcare providers [46].
Saleem Z. *et al*., 2019	A qualitative approach using a semi-structured interview guide was employed for this study. The interviews involved community pharmacists in Lahore, Pakistan.	The results of the study have shown that pharmacists have limited knowledge with regard to AMR, AMS programs, and other related guidelines. However, all of them agreed that appropriate actions are needed to rationalize antimicrobial use in the future [47].
Rizvi *et al*., 2018	A survey was created to learn more about community pharmacists' perceptions, practices, and knowledge about AMS. For this study, a convenience sample of 140 community pharmacists in Tasmania was employed. For reliability and validity, exploratory factor analysis (EFA) and Cronbach's alpha were used.	Eighty-five of the 140 community pharmacists responded to the survey yielding a response rate of 61%, with the majority of respondents being female (65%). A wide distribution of age and experience was noted among the participants ranging from 23 to 70 years and 1-50 years, respectively [48].
Mohammed *et al*., 2021	On March 6 and 7, 2021, a community-based explanatory sequential mixed method was used. The quantitative technique included all registered professionals, which used a cross-sectional study design centered on the community. Version 20 of the social sciences statistical software is used for inferential and descriptive statistics. Then, for a qualitative study, a phenomenological study design was used, and content analysis was carried out.	More than half (54.9%) of community pharmacy professionals had good knowledge, perceptions, and practice on AMS. Key informants stated that inappropriate use of antibiotics resulted in the depletion of normal flora and occurence of a hypersensitivity reaction [49].
Saha*et al*., 2019	The PRISMA extension for scoping review (PRISMA-ScR) checklist and the seven-stage methodology framework outlined by Arkey and O'Malley were used to perform this study utilizing a scoping review approach.	Most community pharmacists perceived that AMS improved patient care and reduced inappropriate antibiotic use. Moreover, CPs educated patients and screened guideline compliance with antimicrobial prescriptions [50].
Durand *et al.*, 2021	Semi-structured qualitative interviews were conducted with community pharmacists in France. Participants were recruited through a professional organization of community pharmacists combined with a snowballing technique. The Consolidated Framework for Implementation Research was used while developing the interview guide and carrying out thematic analysis.	All the respondents had good awareness of antimicrobial resistance and believed community pharmacists had an important role in tackling AMR. Some barriers to community pharmacists' participation in AMS were identified, such as difficult interactions with prescribers, lack of time, and lack of access to patient medical records and diagnosis [51].

Community pharmacists are well aware of the integral role they need to fulfill in the fight against antimicrobial resistance (AMR), especially as drug experts in the healthcare system. They show a good understanding of the causes of antimicrobial resistance and believe that they are competent to conduct or provide AMS programs for the benefit of the community [52]. With the implementation of antimicrobial stewardship programs, pharmacists believe that it can be a means to reduce inappropriate prescription and use of antimicrobials, improve clinical outcomes, and decrease the rate of emergence of AMR [53]. However, the practice of pharmacists in AMS programs is still lacking, as shown in the table. Most pharmacists do not follow the guidelines and continue to dispense antimicrobials without a prescription [42][43].

Despite being familiar with AMS programs, some pharmacists still need more training and access to guidelines for the proper implementation and practice of AMS activities [45]. There are many perceived barriers to the implementation of AMS programs, especially in community pharmacies, barriers demonstrated by pharmacists such as organizational, resources, and especially personal barriers [52]. However, despite community pharmacists' hurdles, most pharmacists still agree that appropriate actions are needed for the rational use of antimicrobials in the future [47]. In another literature, five community pharmacist-led interventions, namely, Collaborative Practice Agreements (CPAs), point-of-care (POC) testing, patient consultations, academic detailing, and advocating for patients and healthcare providers, which can serve as a foundation for the implementation of AMS programs [46].

Nevertheless, AMS strives to enhance patient care and lower healthcare expenditures related to infections through coordinated interventions on the selection, dose, dose regimen, side effects, drug interactions, and allergies to prescribed antibiotics [50]. Community pharmacists' pharmaceutical expertise, as well as their accessibility and close relationship with patients, could promote better utilization of antibiotics by patients and prescribers [51]. Community pharmacists can also play an integral role in AMS programs within community settings, such as delivering value-added services beyond their traditional dispensing duties; they are one of the most frequently seen healthcare professionals and serve as the first point of contact for seasonal viral respiratory tract infections, and community pharmacists are often liaising between patients and various service providers and are well positioned to operationalize any AMS framework [49].

Conclusion

Upon reviewing the results of the gathered literature, it was shown that community pharmacists are among the healthcare professionals who are pivotal in addressing the alarming rate of antimicrobial resistance worldwide. Community pharmacists are especially responsible for the community's safety, as they are the primary point of care for patients before the hospital and are more easily accessible. As drug experts, community pharmacists have extensive knowledge of the cause of antimicrobial resistance and are equipped with rational drug use, which encompasses the proper prescribing, patient adherence to the regimen, medication use regarding the right indication, and such to reduce the cases of antimicrobial resistance. Antimicrobial stewardship programs (ASPs) led by community pharmacists help monitor the purchase and use of antimicrobials, especially in cases where patients present with no prescription. With this, pharmacist-led ASP interventions show a decrease in the number of antibiotic orders or medications sold, as well as cases of Clostridium difficile infections (CDI), methicillin-resistant Staphylococcus aureus (MRSA), and vancomycin-resistant enterococci (VRE) caused infections. Furthermore, evidence also implies that physicians encourage cases to be reviewed by the ASP team and that enhanced collaboration between other healthcare professionals must be adapted. Despite all these benefits, there are still certain challenges surrounding the implementation of ASPs in terms of compliance of health professionals to the actual program, and a proper plan to carry out the program is a must to ensure its success. In the end, ASPs are only highly effective when both parties, pharmacists and patients alike, collaborate to ensure quality healthcare regarding the safe and proper use of antibiotics in the fight against antimicrobial resistance.

Compliance with Ethical Standards

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Disclosure of Conflict of Interest

The authors declare that they have no conflict of interest in this work.

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