



Protocol

# Development of an Optimal Short Course for Pharmacy Students in Sri Lanka to Enhance the Knowledge of Antimicrobial Resistance

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## Abstract

Antimicrobial resistance (AMR) has been identified as one of the greatest threats to human health. Healthcare professionals play a pivotal role in patient care activities, and an understanding of antimicrobial agents and AMR is a critical component of high-quality care. Pharmacists are experts in medicines, and their education and training can directly impact the quality of services they provide to patients. Antimicrobial stewardship (AMS) competencies for pharmacy students have been developed and implemented in the developed world. However, in developing countries like Sri Lanka, there is a gap in the training of pharmacy students in AMS competencies, thereby hindering their ability to be effective in stewardship activities upon graduation.

This study presents a protocol that includes learning outcomes and content to explore a national consensus on AMS competencies that will improve knowledge about antibiotics and AMR in pharmacy students in Sri Lanka. The first draft of the proposed curriculum was developed through a literature review, informed by extensive investigations of pharmacy students' current knowledge and understanding and ensuring suitability in the Sri Lankan context. A process of liaising with academics and stakeholders in Sri Lanka and discussions with academics from developed countries (such as Australia) was used to prepare the final draft. Future consultation and implementation will also seek further input from current and recently graduated pharmacy students in Sri Lanka. The competencies developed will apply to pharmacy undergraduate programs in Sri Lankan universities and for practicing Sri Lankan pharmacists in a continuous professional development program. Once implemented, this protocol will help strengthen AMS education amongst pharmacists in Sri Lanka and ultimately benefit Sri Lankan consumers and assist other health care professionals addressing AMR.

**Keywords:** Pharmacy education; Health Sciences students; Antimicrobial resistance; Antimicrobial agents; Antimicrobial Stewardship

## Introduction

The increasing prevalence of multi-drug resistant infections represents a major threat to global health (1). The World Health Organization (WHO) has warned that without immediate action, we will return to the pre-antibiotic era when common infections were often fatal (2). WHO implemented a global action plan on antimicrobial resistance (AMR) to overcome this challenge in 2015. Healthcare professionals' education and training is one of five key action areas in this global AMR plan (2). Education is a

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fundamental tool to combat AMR and is necessary to deliver effective and safe care (3). Education of health care students' knowledge of antibiotics is crucial (4). Various healthcare disciplines, such as medicine, dentistry, pharmacy, nursing, and veterinary science, are in a position to prescribe antibiotics and influence the use of antibiotics (5). Hence, adequate education and training is essential for these disciplines to ensure optimal use of antibiotics in hospital and community settings.

Pharmacists are essential members of the healthcare team and play an important role in medicine management and the appropriate use of medicines, including antibiotics (6). Undergraduate education provides an opportunity to prepare competent pharmacists to deliver effective professional roles in the community (7). Continuous professional education and development is another important tool for practicing pharmacists to improve their knowledge of antibiotics and AMR (8). Many developed nations have realized the importance of antimicrobial stewardship (AMS) courses for pharmacy professionals and have started to include these competencies in their undergraduate programs (5, 9). However, AMS programs for undergraduate pharmacy students in developing countries have not been widely established. In these countries, antimicrobial courses within undergraduate pharmacy programs tend to focus on basic microbiology, the classification and use of antibiotics, and therapeutic drug monitoring (10). Research shows that pharmacy students believe that robust knowledge of antimicrobials is important for their pharmacy careers and desire more education on rational antimicrobial use (11). Several studies have reported the need for enhanced antimicrobial education during undergraduate degree programs (12, 13). These studies demonstrated inadequate education about antibiotics and AMR in health care educational programs. After graduation, a professional curriculum on AMS has shown improved knowledge and attitudes toward judicious antibiotic use and collaboration with healthcare colleagues (14).

Our recent study (15) from Sri Lanka demonstrated that pharmacy education is clearly associated with an improved understanding of appropriate antibiotic use and AMR among senior undergraduate pharmacy students (15). Another recent publication by the authors compared knowledge and use of antimicrobials among pharmacy undergraduate students in Sri Lanka and Australia (16). This report identified gaps in knowledge and use of antimicrobials among Sri Lankan pharmacy students (16). These studies indicate a need to minimize these gaps in pharmacy students attending Sri Lankan universities.

This study, therefore, aims to develop a suitable curriculum for pharmacy students in Sri Lankan universities that will enhance their knowledge of antimicrobials and AMR and stewardship activities. The aim is to provide a module that can be incorporated into the undergraduate pharmacy curricula and assist future capacity building initiatives through education that will mitigate the emergence and threat of AMR. Furthermore, this curriculum aligns with the WHO competency framework for health workers' education and training on antimicrobial resistance in order to produce a standardized curriculum (17).

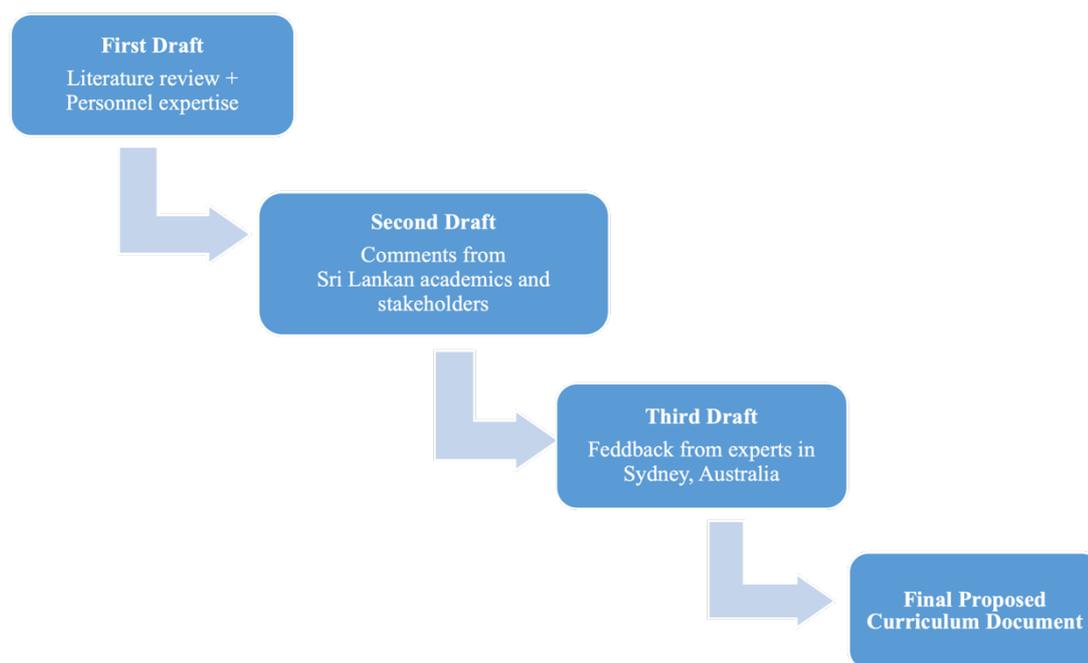
## **Methods**

### *Module development*

Strategies followed for developing the AMR curriculum for pharmacy students in Sri Lankan universities are shown in Figure 1.

The first draft of the proposed curriculum that included learning outcomes, subject topics, and content was developed through a literature search strategy. The following 'Medical Subject Headings' (Mesh) terms were used to search articles in databases such as EMBASE and MEDLINE: (Education.mp) OR (Pharmacy education.mp) OR (undergraduate professional education.mp) OR (Health professional education) AND (Antimicrobial stewardship.mp.) OR (Antibiotics.mp) OR (Antimicrobial resistance.mp) AND (Pharmacy.mp). In addition to this search strategy, the WHO's recently published AMR competency framework for healthcare professionals (17) was taken into consideration. Recent publications on AMR curriculum development and implementation for various healthcare professionals in South Asian countries were also taken into consideration.

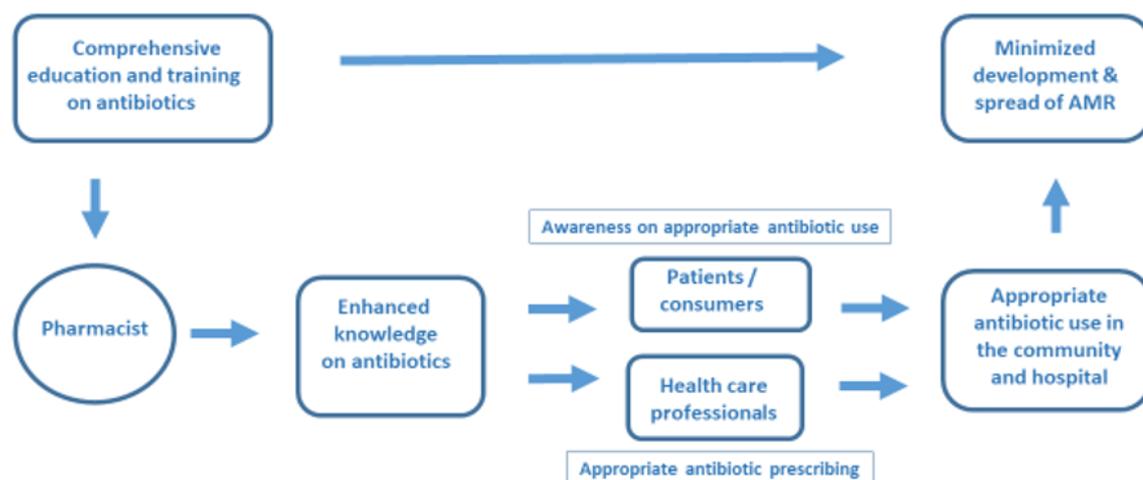
Furthermore, the experiences of the lead researcher/academic (MHFS) regarding the local academic and healthcare systems were also considered during the preparation of the first curriculum draft. The acquired knowledge and skills while working as an academic at a Sri Lankan university was an important aspect since the researcher (MHFS) worked as a resource person to develop the B. Pharm curriculum when it was first introduced to Sri Lanka in 2005 at the University of Peradeniya. The researcher (MHFS) had also assisted in B. Pharm curriculum reviews at three different universities in Sri Lanka during 2011, 2012 and 2014.



**Figure 1.** Strategies for the development of optimal AMR curriculum for pharmacy students in Sri Lankan universities

The development of the second draft incorporated feedback from Sri Lankan academics and stakeholders via e-mail communications. Learning outcomes and the content outlines of the first draft were discussed, and review recommendations were incorporated. For the preparation of the third draft, feedback was obtained from academic and clinical experts at the Sydney Pharmacy School and NSW Therapeutic Advisory Group. These individuals have extensive experience in the pharmacy curriculum and ample knowledge about antibiotics and AMR. The final draft was prepared by incorporating recommendations from the collective discussions and feedback from the Sri Lankan and Australian contributors.

Figure 2 demonstrates how comprehensive education and training about antibiotics and AMR for pharmacists can reduce the development and spread of AMR in the community and hospitals. This figure explains how this can be achieved through different strategies such as providing awareness of antibiotics and AMR to patients and consumers in the community. Furthermore, providing appropriate advice on antibiotic use for consumers in the community and unnecessary/inappropriate prescribing of antibiotics to prescribers in the hospital.



**Figure 2.** Comprehensive education and training on antibiotics for pharmacists to reduce the development and spread of AMR

## Results

The learning outcomes and the content of this curriculum were prepared in reference to selected articles from the literature (18-21). This curriculum was prepared to fit the local context, aligning with recently published WHO guidelines on AMR education for healthcare professionals, particularly pharmacists (17). The curriculum development process (Figure 1) leads to considerable refinements of the first curriculum draft. In this curriculum, WHO guidelines are considered a general guide, and the local context incorporated is considered a special case.

Table 1 lists the main domains and learning outcomes for this newly proposed curriculum that seeks to produce competent pharmacists with a detailed understanding of the national and global challenges of AMR and the evidence-based stewardship interventions that will mitigate these challenges in hospital and community settings. The resulting curriculum covers six domains: infection and surveillance, antibiotics and antimicrobial resistance, infection and prevention control, quality use of antimicrobial agents, patient education and counseling, and interprofessional collaborative practice. Table 2 provides further details on each topic. The proposed AMR course curriculum will include topics such as antimicrobial agents, antimicrobial resistance, infectious diseases, principles of infection management, patient-centered care, and antimicrobial stewardship. A detailed content to be taught under each topic is also included in Table 2.

## Discussion

Standardized curricula content that aligns with the WHO competency framework for health workers' education and training on AMR can enhance the impact of AMR and AMS education and improve suboptimal practice (17). In this project, a curriculum has been designed and proposed to improve knowledge of antibiotics and AMR among Sri Lankan pharmacy students and practicing pharmacists. This curriculum can be incorporated into all Sri Lankan universities teaching pharmacy. The competencies developed in this curriculum aim to fill the current gaps in the AMS education of the Sri Lankan pharmacy profession. The gaps in knowledge about antibiotics among pharmacy students in Sri Lankan universities have been addressed in our earlier publications (15, 16) which rationalize the need for developing a new curriculum to enhance the knowledge regarding antibiotics and AMR.

**Table 1.** Competency domains and proposed learning outcomes of AMR course

<b>Domain</b>	<b>Proposed learning outcomes</b>
Infection and surveillance	At the successful course completion, the students will be able to: <ol style="list-style-type: none"> <li>1. explain how microbiology testing leads to the diagnosis of infection</li> <li>2. describe the data on infectious diseases at national and regional level</li> </ol>
Antibiotics and antimicrobial resistance	At the successful course completion, the students will be able to: <ol style="list-style-type: none"> <li>1) define antimicrobial resistance (AMR) and appropriate antimicrobial use</li> <li>2) describe the factors that contribute to antimicrobial resistance</li> <li>3) describe the current and future potential status of AMR</li> <li>4) describe at least two different mechanisms of action by which antibiotics treat infections</li> <li>5) describe the challenges and impact of AMR at national and regional levels               <ol style="list-style-type: none"> <li>a. describe the appropriate use of antimicrobial agents in humans, food production and agriculture</li> </ol> </li> </ol>
Infection and prevention control	At the successful course completion, the students will be able to: <ol style="list-style-type: none"> <li>1) define the term microorganism.</li> <li>2) describe different types of infectious microorganisms</li> <li>3) recognize the symptoms of infection</li> </ol>
Quality use of antimicrobial agents	At the successful course completion, the students will be able to: <ol style="list-style-type: none"> <li>1) identify the roles of the community and hospital pharmacists in facilitating rational prescribing of antimicrobial agents</li> <li>2) select an appropriate antimicrobial drug (when a drug is needed). individualise dose selection and make recommendations on frequency and duration of use</li> <li>3) know the importance of monitoring antimicrobial agents to inform their optimal and safe use</li> </ol>
Patient education and counselling	At the successful course completion, the students will be able to: <ol style="list-style-type: none"> <li>1) apply patient-centered interventions such as education and medication counselling to improve judicious and appropriate antibiotic use</li> </ol>
Inter-professional collaborative practice	At the successful course completion, the students will be able to: <ol style="list-style-type: none"> <li>1) apply multidisciplinary problem-solving approaches, including pharmacist-led interventions to address antimicrobial resistance and rational use of antimicrobial agents</li> </ol>

These differences in the knowledge base of future pharmacists highlight the need for mapping a curriculum, which will lead to workforce capacity development. Importantly, introducing this new curriculum in Sri Lanka aligns with the workforce development goals of the International Pharmaceutical Federation (FIP) (22), which are undertaken to expand future capacity development and improve medication use. This curriculum is now proposed to be incorporated into the undergraduate pharmacy training and introduced as a continuous professional development program for practicing pharmacists. This curriculum provides a foundation for Sri Lankan pharmacy professionals to become leaders and advocates for AMS. Moreover, this curriculum will be useful for pharmacists to be involved in AMS-related medicine management activities and actively engaged in patient care.

**Table 2.** Topics and contents need to be included in the proposed AMR course curriculum to be implemented in Sri Lanka

Topics	Contents
Antimicrobial agents	Introduction to antimicrobial agents, the spectrum of activity, principles of empirical vs. directed antimicrobial therapy, pharmacology (including pharmacokinetics, ADME), mechanism of action and adverse effects. Significance of antimicrobial choice, dosage, duration and national medicines regulations on antibiotics, antiviral and antifungal agents
Antimicrobial resistance	Introduction to AMR, contributing factors for the development and spread of AMR, genetics and mechanisms, extent and causes, and relationship to antibiotic use. Use of antimicrobial agents in food production and agriculture and how this contributes to the spread of AMR. Local AMR patterns and their importance including AMR trends in regional and national AMR data
Infectious diseases	Standard infection prevention and control precautions, explain the link between antimicrobial stewardship and infection prevention control, explain the impact of nosocomial infections compared with community-acquired infections, use of microbiology samples and rapid point-of-care testing to identify infections
Principles of infection management	Importance of antimicrobial administration timing, determine and verify antibiotic allergies, reconcile and adjust antibiotics, report adverse drug reaction at all transitions and changes in patient's condition, importance of monitoring toxicity reliably and how to make dose adjustments
Patient centred-care	Techniques in advising patients and the prescribers on the appropriate use of antimicrobial agents, safe disposal of unused antimicrobial medicines, patient safety and medication adherence, and use of antimicrobials in compliance with formulary protocols, assessment of information and pharmaceutical products as part of good procurement practices. Techniques to use in patient discussions on why an antibiotic is not necessary and prudent antibiotic use
Antimicrobial stewardship	Definition of antimicrobial stewardship (AMS), contribution of appropriate antimicrobial use to reduction of AMR, principles of good antimicrobial prescribing and the roles of prescribers, pharmacists and nursing staff in ensuring good practice including prescription-only dispensing practices. Pharmacists' interventions to prevent health-associated infections, unnecessary prescribing of antimicrobial agents, national antimicrobial strategy and policy, AMS initiatives in developing countries and its significant outcomes

In Sri Lanka, antibiotic stewardship activities are emerging (23). Much needs to be done to improve education in this area. There is an urgent need to develop and evaluate new and improved education techniques, curriculum content, and interventions that not only increase knowledge and understanding of antibiotics and AMR but improve antibiotic use, dispensing practices, and management. Pharmacy students in Sri Lanka do not have a course that specifically focuses on AMR. Although antibiotics are discussed in several different modules, such as microbiology, pathology, pharmacology and pharmacotherapeutics, there is limited attention given to AMR. The strength of the proposed curriculum is that it draws on evidence-based design aspects to integrate information and training in AMR delivered to the student/pharmacists in patient care centered context. One limitation of this approach to curriculum development is that there was limited consultation with current and recently graduated pharmacy students in Sri Lanka. This will be an important aspect of the implementation of the proposed curriculum.

While there is a clear need to develop standardized curricula of antibiotic stewardship in Sri Lanka for all healthcare professionals, including pharmacists, it is also important to consider the postgraduate competencies of all Sri Lankan healthcare professionals to ensure appropriate antibiotic prescribing, dispensing, and management. Postgraduate pharmacy interns should be held accountable to master and

demonstrate these essential competencies. The proposed curriculum will assist professional regulators and curriculum reform committees in Sri Lanka, given the evolution of the pharmacists' role in direct public health and patient care.

For practicing pharmacists, continuing professional education provided by hospitals, national professional pharmacy / medical societies, and public health entities should include education on antimicrobial stewardship (24). A coordinated and multifaceted educational approach, in combination with other current and future antibiotic stewardship activities, is critical to improving antibiotic use, reducing adverse events caused by antibiotics, and attenuating the development and spread of antibiotic resistance.

It is recommended that this developed curriculum for Sri Lankan pharmacists is implemented in the near future. Post-curriculum implementation, simulated client (SC) visits could be employed to explore the appropriate dispensing, advice, and counseling of antimicrobial agents at community pharmacies in Sri Lanka (25). The SC visits would support an audit and feedback model for quality improvement of pharmacists' practice. This evaluation model would further inform any enhancements that might be required to the curriculum. In addition, this curriculum could be extended to Sri Lankan allied health professionals, such as nurses, radiographers, physiotherapists, and medical laboratory scientists, strengthening their knowledge of antibiotics and AMR and enabling these professionals to practice and also reinforce critical messages and activities that will reduce the emergence of AMR in Sri Lanka.

## Conclusion

This curriculum was developed to provide pharmacy students with the necessary competencies to ensure the appropriate use of antimicrobial agents and better understand the national and global challenges of AMR. This curriculum provides a clear pathway for career progression. We suggest that this curriculum be incorporated into the pharmacy academic programs in Sri Lankan universities. This would produce pharmacists with enhanced knowledge on the appropriate use of antibiotics and the harm of inappropriate use. Eventually, these competencies can be applied to their work as professional pharmacists and potential patients. Further work is needed to extend the scope of this curriculum to encompass certificate and diploma level pharmacist training.

**Author Contributions:** MHFS, AAB and AJM were involved in the development and designing of the protocol. MHFS data collection instrument and data collection. MHFS, and AJM performed data analysis and interpretation. MHFS original draft preparation. MHFS, AAB, and AJM revised and approved the submission of the final manuscript.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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