Enhancing Pharmacy Students' Understanding of Antibiotics through Educational Interventions

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Received: 13-05-2025; Revised: 07-06-2025; Accepted: 21-06-2025; Published: 07-07-2025

Abstract

The problem of antibiotic resistance is one of the greatest threats to global health, and future healthcare professionals need to be educated to help curb the dissemination of the issue. The research is aimed at exploring how specifically designed educational interventions may influence antibiotic literacy and awareness in pharmacy students of one of the Japanese universities. We used a structured questionnaire to determine the baseline knowledge, perception and behavioural intention of students towards the use of antibiotics prior to and after an academic module on antimicrobial stewardship. The results indicated a significant increase in students scores pertaining to the comprehension of the mechanisms of antibiotics, the problem of resistance, and correct prescribing practices after the intervention. The findings highlight the need to incorporate extensive antibiotic training into the pharmacy school curriculum that will allow preparing future pharmacists to confront antimicrobial resistance with proper knowledge.

Keywords: ***Antibiotic literacy, Pharmacy education, Antimicrobial resistance, Student awareness, Japan, Antibiotic stewardship, Healthcare education, Questionnaire survey, Pharmacy students, Public health.***

1. Introduction

1.1 Background and Global Context

The development of antimicrobial resistance (AMR) is one of the most urgent problems that modern medical care faces in the global community. This effect promises to erode decades of medical advancement, and make standard surgical procedures, and treatment of common infections life-threatening once more. World Health Organization declared AMR as one of the ten leading global public health threats to humankind, thus the necessity to develop a concerted effort to address this issue in several areas of societal concerns.

To deal with this growing crisis, many countries have introduced detailed national plans that focus on the battle against the spread of the resistant microorganisms. Such efforts usually include several elements, such as surveillance programs, infection precaution measures, research and development programs, and most importantly, education programs aimed at increasing the level of antimicrobial stewardship behavior among health providers and the general population(1).

1.2 Japan Strategic Response to Antimicrobial Resistance

Japan is one country that has been quite systematic and well-coordinated in its approach to AMR. In 2016, the Japanese health authorities launched a National Action Plan (NAP) on antimicrobial resistance (AMR) following the Global Action Plan on Antimicrobial Resistance established by the World Health Organization. This multi-faceted plan had particular goals and quantifiable milestones to achieve the reduction of inappropriate antimicrobial usage without limiting the possibilities to effectively treat patients having bacterial infections.

At the core of the NAP in Japan is the understanding that educational interventions among health workers form one of the core elements of any effective antimicrobial stewardship program. The plan particularly underscores the necessity of fostering evidence-based prescribing habits among the physicians and improving the knowledge base of other healthcare providers such as the pharmacists, nurses, and allied health professionals.

Among the policy advances that were among the most notable as the results of this national strategy was the issuing of clinical guidelines in 2017 by the Ministry of Health, Labour and Welfare concerning the proper management of acute upper respiratory tract infections. These guidelines are specifically aimed at common cold and other viral syndromes conditions, which antibiotics are often prescribed inappropriately even though they are ineffective against viral pathogens.

1.3 The Essential Value of Pharmacy Education

Pharmacists have a special role in the healthcare system, as they represent the last line of defense before patients get

antimicrobial drugs. Their scope of practice goes beyond mere dispensing to the point of counseling patients, medication therapy management, and coordination with the prescribing doctors to ensure the best possible outcomes of the treatment. Clinical pharmacists are becoming active members of the antimicrobial stewardship team in a hospital, where they offer their services in drug choice, dose optimization, and therapeutic monitoring.

However, the identified significance of pharmacists participation in antimicrobial stewardship reveals wide gaps in educational preparation of pharmacy students in Japan. The Model Core Curriculum for Pharmacy Education that has been developed by the Ministry of Education, Culture, Sports, Science and Technology offers a guideline on the structured pharmaceutical education that covers six years of undergraduate education(2). Nonetheless, this curriculum has focused on the fundamentals of pharmaceutical sciences such as microbiology, pharmacology, and pathophysiology, but it has not paid sufficient attention to the practical elements of antimicrobial stewardship.

The first four years of studies usually constitute the basis of knowledge of students with fundamental aspects like microbial biology, drug action, and pathogenesis of diseases being taught. The fifth year is devoted to advanced clinical training in hospital and community pharmacy practice areas where students get experience in direct patient care. But incorporation of antimicrobial stewardship principles along this learning process has been both uneven and mostly in inadequate measures.

1.4 Educational Problems and Faculty Constraints

The lack of faculty with special skills and knowledge in clinical infectious diseases and antimicrobial stewardship is one of the most critical impediments to improving antimicrobial education in Japanese pharmacy schools. This restriction has significant consequences of curriculum development and implementation because the effective teaching in this field needs not only theoretical background but also the practical one in the sphere of clinical decision-making and patient care.

Antimicrobial stewardship is more complex than merely drugs choice, it incorporates the understanding of pharmacokinetics and pharmacodynamics, mechanisms of resistance, diagnostic stewardship, and interdisciplinary collaboration. An effective way of teaching these concepts requires faculty members that are able to make the connection between basic science knowledge and clinical practice, and assist students in seeing how the basic principles can be applied to actual patient care situations(3).

1.5 Ignorance Gaps and Learning Performance

Past studies looking into the antimicrobial knowledge and attitudes of Japanese healthcare students have shown alarming gaps in knowledge. Surveys of medical and pharmacy students have shown that a significant number of graduates proceed into clinical practice with an incomplete understanding of when and how to use antimicrobials, especially in treating such common diseases as viral respiratory tract infections.

These gaps in knowledge are presented in a number of ways which are the inability to differ between bacterial and viral infections, wrong ideas about the effectiveness of antimicrobials against viral syndromes, problems in determining the appropriate antimicrobial agent, poor comprehension of resistance, and its prevention. These gaps are of great concern to the further clinical practice as they may cause further improper prescribing and poor patient outcomes.

1.6 Rationale and objectives of study

Considering the overwhelming significance of the pharmacists role in antimicrobial stewardship and the revealed weaknesses of the existing educational strategies, the efficient measurement of specific educational interventions in students knowledge and attitudes is urgently needed. The examination of the effectiveness of certain teaching methods on student learning outcomes may guide the further development of the curriculum and determine the optimal practices in antimicrobial education.

The aim of the study was to examine the prevailing situation with regard to antimicrobial knowledge and literacy in pharmacy students in one of the major universities in Japan and to determine the changes produced by a targeted educational program on the same issue, namely, the proper management of acute upper respiratory tract infections. The investigation of the modification of the knowledge, attitudes, and clinical experiences of students in various phases of their education allowed us to determine the most effective methods of antimicrobial stewardship education and establish the foundation of future curricula development.

The results of this study not only in Japan but also in other countries with similar issues in training healthcare workers to treat the rising challenge of antimicrobial resistance.

2.Methods

2.1 Research Design and Conceptual Framework

The study was a quasi-experimental longitudinal study aimed at assessing the efficacy of purposeful antimicrobial stewardship education in undergraduate pharmacy students. The research was based on the mixed-method, which helped to use both the quantitative survey data and the qualitative evaluation of the clinical experiences in order to present the full picture of the educational outcomes. The theoretical basis of the research consisted of the educational theory and, more particularly, the four-level evaluation model by Kirkpatrick, according to which the learning outcomes are measured in the reaction, learning, behavior, and result dimensions(4).

To increase the validity of findings and help address the confounding variables, the study design included many comparison groups. The ability to repeat the students in the various points in their educational path and comparing the cohorts with and without the specific educational interventions allowed us to isolate the effects of targeted educational antimicrobial stewardship training whilst controlling for the natural course of knowledge acquisition during the pharmacy curriculum.

2.2 Institutional Setting and Characteristics of the Participants

This study was performed in Showa University School of Pharmacy, which is an exemplary established pharmaceutical educational institution that represents the pharmacy schools in Japan. This school adheres to the national model of pharmacy education that lasts six years, as dictated by Japanese educational standards, making it a perfect choice of studying the effects of changes in the curriculum within the boundaries of the current education model.

The research population was the undergraduate pharmacy students in the first and fifth-year programs in the 2019 and 2023 academic years. First-year students were chosen because they demonstrate the initial point of knowledge of new pharmacy students, who finished their general education coursework but have not yet obtained any specialized training in pharmaceuticals. The reason fifth-year students were selected is that they were considered to be the most advanced in the undergraduate level since they had finished the basic pharmaceutical sciences course work and were about to go into clinical training experiences.

The selection of participants was based on the census method where all the students within the targeted academic years were invited to take part in the survey components. This maximizing sampling plan was selected in order to optimize statistical power and to guarantee representational results that may be extrapolated to comparable educational facilities. Having cohorts in several years enabled the determination of temporal trends, as well as assessing sustainability of interventions.

2.3 Development and Implementation of Educational Intervention

The main educational intervention involved a detailed 90-minute lecture on the topic of antimicrobial stewardship principles in acute upper respiratory tract infections in particular. The session was cleverly scheduled just before the fifth-year clinical training experiences of the students to ensure the greatest degree of practical applicability and practical use of the presented material.

The content of the lectures was carefully constructed on the basis of evidence-based clinical guidelines, mainly the Manual of Antimicrobial Stewardship issued by the Ministry of Health, Labour and Welfare of Japan. The curriculum covered typical viral respiratory diseases such as the common cold, pharyngitis, and sinusitis, especially the difference between bacterial and viral causes and when antimicrobial therapy is indicated and not indicated in each case(5).

The speaker who presented the educational session is a board-certified infection control pharmacy specialist who has considerable clinical experience in antimicrobial stewardship. This educator was also certified as an Infection Control Pharmacy Specialist and Infectious Diseases Chemotherapy Pharmacist which guaranteed the excellent knowledge of the subject matter. The involvement of a special instructor was meant to provide a model of how such expert-directed education ought to be deployed ideally in all pharmacy schools around the nation.

Pedagogical strategy The teaching modality involved the use of a variety of modalities that included didactic presentation, case-based learning scenarios and interactive discussion elements. The clinical vignettes were purposely chosen as they exemplified typical scenarios in which pharmacy students will most probably find themselves once in their clinical training and careers. The methodology was planned to maximize knowledge

retention and learning transfer from the teaching to practice environments.

TABLE 1 Participant Demographics and Response Characteristics

Academic Year	Survey Period	Total Eligible	Respondents	Response Rate (%)	Gender Distribution	Mean Age (years)
First-year 2019	May 2019	204	202	99.0	58% F, 42% M	18.7 ± 0.8
Fifth-year 2019	April 2019 (Pre-clinical)	178	146	82.0	61% F, 39% M	22.4 ± 1.2
Fifth-year 2019	November 2019 (Post-clinical)	177	171	96.6	60% F, 40% M	22.8 ± 1.1
Fifth-year 2023	January 2023 (Pre-clinical)	194	170	87.6	62% F, 38% M	22.3 ± 1.0
Fifth-year 2023	November 2023 (Post-clinical)	185	160	86.5	59% F, 41% M	22.7 ± 0.9

2.4 Design and validation of a survey instrument

The main data gathering tool was a self-administered questionnaire based on proven survey questions of the nationally representative Antibiotics Awareness Survey 2018 of Japanese citizens. This baseline gave us a uniform Comparative Base and it made sure that we could place our results in the context of overall population health literacy testing.

The questionnaire contained 7 main questions (Q1-Q7) which covered various aspects of antimicrobial knowledge and literacy. These questions were specially chosen to help test not only factual knowledge (like knowledge of the mechanisms of antimicrobials and correct indications) but also attitudinal (like compliance behaviors and disposal). There were also some additional questions that ensured to get the data regarding the experience of clinical training and meditation counseling activity (6).

Question types comprised basic antimicrobial knowledge, mechanisms of action knowledge, knowledge of indications of specific diseases, ability to identify drugs, ability to determine necessity of treatment, adherence and completion rates, and disposition of leftover medication. To be able to appreciate subtle levels of learning, each question had several possible answers to choose with the forced dichotomous choices being avoided in the questionnaire as they may not adequately represent the current knowledge state of students.

The survey tool was extensively pilot tested using a small sample of pharmacy students to determine whether there were any possible sources of ambiguity, the time necessary to complete the survey as well as the suitability of the response categories. The final instrument design included the feedback provided by the pilots participants to promote a better understanding and ease of use.

2.5 Data collecting procedures and time schedule

The procedure of data collection had a systematic protocol that was aimed at producing consistency in all the administrations of the survey and reducing the possible sources of biases. The survey was conducted in paper-based format to earn everyone access and lessen the impediments of technology that could influence response rate and the quality of data(7).

The timeline of data collection included several time points to allow collecting cross-sectional variations between cohorts of students as well as longitudinal changes within the same groups. The baseline data were acquired in May 2019 among the first-year students, and it reflects their state of knowledge at the moment of entering the specialized pharmaceutical education. The survey of fifth-year students was conducted at two important moments: right before their clinical training experiences (April 2019) and upon finishing clinical rotations (November 2019).

The additional data collection was performed in 2023 in a different cohort of fifth-year students to evaluate the sustainability and the possibility of generalizing the educational interventions. This time-based comparison made it possible to assess the intervention effects under diverse student groups and learning conditions.

Each and every administration of the survey was done at regularly scheduled class time so as to get the highest response rate as possible and to have a representative sample. The purpose and procedures of the research were

detailed explained to students and participation was on a voluntary basis without any academic implications of non-participation.

TABLE 2 Clinical Training Experience Assessment

Clinical Activity	Fifth-year 2019 Post-clinical (%)	Fifth-year 2023 Post-clinical (%)	Clinical Significance
Antimicrobial Counseling Provision			
Provided any counseling	87.1	83.1	High clinical exposure
Condition-Specific Counseling			
Common cold	49.7	53.4	Persistent inappropriate use
Bacterial sinusitis	34.2	28.6	Appropriate bacterial infection
Dental prophylaxis	38.9	26.3	Procedural indication
Urinary tract infection	26.8	22.6	Clear bacterial indication
Patient Education Topics			
Completion importance	78.4	82.1	Resistance prevention
Side effect monitoring	65.2	71.3	Safety awareness
Drug interaction assessment	42.7	48.9	Clinical pharmacy role

2.6 Ethical Issues and institutional Review Board Approval

The Showa University Research Ethics Committee thoroughly reviewed and approved the research protocol (Approval numbers 349 and 22-192-B), and all the ethical standards that apply to human subjects research were considered. The research protocol was designed and carried out following the Declaration of Helsinki and Japanese national recommendations on ethical conducting of research with human subjects (8).

There were informed consent processes involving written elaboration on the objectives of the research, the means of data collection, confidentiality and the rights of the participants. Each survey contained direct consent procedures, and their participation served as voluntary agreement to use the data in the research. It was made clear to students that answers given in the survey would be anonymous and that no way could the individual answers be traced to academic performance or any other method of identification.

3.Results

3.1 Demographics of participants and response features

The research has got truly impressive turnout rates amongst all the cohorts that have been surveyed, which indicates high student engagement and the rigor of the methodological approach. We achieved an outstanding 99.0 percent response rate (202 of 204 eligible first-year students) in May 2019, providing a comprehensive baseline measure of entering pharmacy student knowledge. The participation of fifth-year students also depended on the time of assessment, at 82.0% (146 of 178 students) during surveys of pre-clinical training in April 2019 and 96.6% (171 of 177 students) after completion of clinical training in November 2019.

Participation in 2023 was equally strong, with 87.6 percent of fifth-year students (170 of 194) completing pre-clinical surveys and 86.5 percent (160 of 185) undergoing post-clinical assessments. Such high response rates at numerous time points and among different cohorts give us very good evidence that our results are likely to be

representative and reduce the possibility of selection bias, which may invalidate the results, to a minimum.

Demographically, the analysis showed some common features of the Japanese pharmacy student populations, where there was equal gender representation and age distribution that was consistent with conventional undergraduate enrollment trends(9). The consistency of demographic features over time between cohorts reassured the reasonable of cross-year comparisons and enhanced internally validity of our longitudinal evaluations.

3.2 Basic Antimicrobial Knowledge Acquiring Patterns

The sequential acquisition of the basic antimicrobial knowledge between the first and fifth year demonstrated that there were dramatic changes in the basic knowledge. Two-thirds (67.2%) of first-year students responded that they had no antibiotic-related terminology familiarity, which can be considered as an indication of low exposure to pharmaceutical concepts in pre-professional education. The standard pharmacy curriculum was effective in eliminating this knowledge deficit, because almost all fifth-year students (98.8-99.0%) were familiar with antimicrobial concepts.

Even more important was the level of insight which displayed extraordinary progress beyond mere familiarization. More than one-third of fifth-year students (27.6-38.1%) said that they knew enough to teach antimicrobial concepts to others, which is a complex degree of understanding that will help them in the future as medication therapy professionals and patient educators.

Mechanistic knowledge of antimicrobial action showed a great consistency in all the sets of students. There was also a great basis among even first-year students with 91.0 percent of the students identifying the inhibition of bacterial growth as the main mechanism of antimicrobial action. There was a modest rise in this percentage amongst fifth year students (94.7-98.8%), which indicates that the fundamentals of mechanistic ideas are firmly entrenched early in pharmaceutical training and then supported throughout the curriculum.

Nonetheless, the decrease in the false beliefs regarding the secondary antimicrobial effects demonstrated significant educational advantages. First-year students were often supportive of wrong ideas concerning antimicrobial abilities, such as fever (18.5%), pain (13.5%), and inflammation (40.0%). All of these misconceptions were significantly lower among the fifth-year students and the beliefs in inflammation suppression dropped to 29.2-35.0%, showing better comprehension of drug-specific therapeutic mechanisms.

3.3 Clinical Application Competency-Disease-Specific Knowledge

The disease-specific antimicrobial knowledge assessment demonstrated the most striking changes in education and showed the particular effect of educational interventions of interest. There were alarming knowledge gaps in the first-year students relating to the proper indication of antimicrobials, as large proportions mistakenly thought that antibiotics could treat viral illnesses such as common cold (45.0%), influenza (46.6%), and norovirus (46.5%).

Conventional pharmaceutical training was found to be successful and unsuccessful in resolving these misconceptions. Viral misconceptions also remained at alarming rates among fifth-year students who had received conventional curriculum and no specific antimicrobial stewardship education: 43.5-43.8% still believed that antibiotics were active against common cold, and 14.7% still held beliefs about the efficacy of influenza.

The effects of special antimicrobial stewardship education were revolutionary to the knowledge of viral infections. Students who got the focused educational procedures showed a significant increase in knowledge, as the common cold misconception reduced to 19.9 percent and the influenza misconception declined to 10.5 percent. These gains are clinically significant and the knowledge advances have immediate relevance to subsequent prescribing advice and quality of patient counseling.

On the other hand, awareness of proper indications of bacterial infection improved uniformly with all the educational methods. The antibacterial efficacy in treating cystitis (15.8% to 80.0-87.1%), pneumonia (25.7% to 75.0-90.1%), and otitis media (11.4% to 70.6-91.2%) proved that standard pharmaceutical training was effective in constructing positive knowledge systems.

3.4 Drug ID and Clinical Recognition Skills

Drug brand awareness is one of the important clinical skills of the working pharmacist. The identification of definite antimicrobial agents demonstrated predictably low results among first-year students with only 16.3 and 19.3 percent of students identifiying amoxicillin and levofloxacin as antibiotics respectively. These recognition rates were significantly higher among fifth-year students and were 81.2-95.0% and 75.3-94.2% respectively of amoxicillin and levofloxacin.

The other source of recognition benefits was offered through clinical training experiences with post-clinical training

assessments recording the highest identification rates. This trend implies that practical experience in the clinical setting with medication dispensing and patient counseling supports the theoretical knowledge and develops practical competence, which is the basis of professional practice(10).

Notably, the students also saw an increase in discrimination of antimicrobial and non-antimicrobial agents. The identification of non-antibiotics, including oseltamivir (antiviral), pravastatin (statin), and indomethacin (anti-inflammatory), revealed proper reduction among fifth-year students, and it reflects the increased specificity in the knowledge of drug classification.

TABLE 3 Response Rate Analysis and Demographic Characteristics

Survey Period	Target Population	Eligible Students	Respondents	Response Rate (%)	Female (%)	Male (%)	Mean Age ± SD
2019 Cohorts							
First-year (May)	Incoming students	204	202	99.0	58.4	41.6	18.7 ± 0.8
Fifth-year Pre-clinical (April)	Advanced students	178	146	82.0	61.0	39.0	22.4 ± 1.2
Fifth-year Post-clinical (November)	Clinical completers	177	171	96.6	59.6	40.4	22.8 ± 1.1
2023 Cohorts							
Fifth-year Pre-clinical (January)	Advanced students	194	170	87.6	62.4	37.6	22.3 ± 1.0
Fifth-year Post-clinical (November)	Clinical completers	185	160	86.5	58.8	41.2	22.7 ± 0.9

3.5 Decision-Making and Development of Clinical Judgment in Therapeutics

Judgments about the necessity of treatment were found to be assessed with highly developed clinical reasoning skills. First year students were often supporters of antibiotics use even in viral ailments with 34.2 percent of the students holding the opinion that common cold required antibiotics. Conventional drug training decreased this figure to 25.4-26.5 percent in fifth-year students, which is a significant yet not sufficient progress.

The targeted antimicrobial stewardship intervention posted better results, as the belief in inappropriate treatment dropped to 14.1 percent in the intervention recipients. This result shows the particular usefulness of special educational methods to cope with tricky situations of clinical decision-making that cannot be reduced to mere pharmacological expertise.

Treatment preferences were appropriately biased towards symptomatic treatments rather than antimicrobial treatments according to symptom. The students were always supportive of proper supportive care interventions such as antitussives (85.3-92.1%), antipyretics (68.3-86.5%), and expectorants (53.5-92.9%) in the management of viral respiratory syndromes, which reflect good therapeutic reasoning and patient-focused care practices.

3.6 Implications of Professional Practice and Attitudes Behavioral

The assessment of compliance behavior identified worrying trends that need to be addressed through specific education. The tendencies to stop using antimicrobials after the symptoms had improved were noted in 38.9% of first-year students, and this characteristic poses a major threat to the overall public health as the connection between the incomplete course of treatment and the emergence of resistance has been established.

Pharmaceutical education revealed a certain effect on compliance attitude, as fifth-year students had less tendency of premature discontinuation (20.6-20.8%). At the same time, the percentage of appropriate completion behavior rose, in first-year students being 37.4 percent, and in fifth-year students being 57.6-58.3 percent, which evidences the positive internalization of proper medication use principles.

The practice related to leftover medication management demonstrated varied educational results. Although the inappropriate storage behaviors (saving to use later) did not differ much among the different levels of study (30.0-42.0%), the correct disposal habits improved significantly between the fifth-year students (21.5-32.2-35.9%). These results indicate a possibility of more effective education on the rules of medication storage and disposal safety.

4.Discussion

The Effectiveness of Paradigm Shift in Pharmaceutical Education

Our study is a pioneering study of educational change in the field of pharmaceutical training, which proves that precisely targeted antimicrobial stewardship interventions can fundamentally change the student knowledge architectures and the development of professional competencies. The extent of the observed knowledge gain in various areas of assessment leads to the idea that the conventional beliefs regarding the curriculum effectiveness might need to be changed significantly. antimicrobial education is important to consider rather than as a basic knowledge transfer process, our findings favour a more complex view of competency development that incorporates cognitive restructuring, misconception correction and professional identity development.

A drop in the misconceptions about viral infection among the recipients of the intervention of 45 percent to 19.9 percent is more than a statistical correction; this is a qualitative change in the clinical reasoning abilities that will affect the work with thousands of future patients. This change implies that, with strategically planned and skillfully offered interventions, pharmaceutical education can attain results that have been believed to come out of long clinical experience.

Our findings defeat the accepted wisdom regarding when and how strongly antimicrobial education should occur during pharmacy education. The overall implication of the finding that a singular 90-minute session was able to yield long-term increases in knowledge when compared to semester-long courses is that education efficiency could possibly be increased by as much as expert-guided, competence gap-specific interventions replace whole course offerings.

Cognitive Architecture Reconstruction and Knowledge Integration

The sequence of learning that we have discovered during our research points to the presence of high-level thinking involved in the development of professional competencies. The fragmented nature of the beliefs held by first year students entering pharmacy education was observed to be correct in regards to antimicrobial mechanisms and indications in most cases. The classic curriculum proved to be effective in developing knowledge networks of the basics, and more than 90 percent of students were able to recognize the bacterial growth prevention as the major antimicrobial action.

Yet, the perseity of viral infection myths beyond the conventional pharmaceutical training indicates the inherent shortcomings of the existing pedagogical methods. Conventional training in microbiology and pharmacology seems inadequate to overcoming long-standing popular assumptions about the action of antimicrobial agents, indicating that educational interventions specifically designed to address this problem are necessary to effect significant correction of misconceptions.

The high efficacy of targeted antimicrobial stewardship education proves the significance of the incorporation of clinical context in pharmaceutical education. Instead of exposing the antimicrobial concepts as separate items, the intervention linked the pharmacological concepts to the real-life clinical situations, thereby enabling the knowledge transfer in the academic environment to the workplace setting.

We found that successful antimicrobial education may need to directly focus on cognitive conflict resolution-forcing a direct challenge to the wrong belief, not merely stating the right information. This method is consistent with constructivist learning theories which state that it is necessary to address the preconceptions of the learners and support the conceptual change with the help of guided discovery and expert modeling.

International Comparative Analysis and Educational Benchmarking

When our results are compared to those of the international studies, there are some reassuring similarities, as well as alarming differences in the patterns of acquiring antimicrobial knowledge. The rates of the viral infection misconception as the baseline (45-47%) among the Japanese first-year students are comparable to the results of American and European pharmacy programs, indicating possible universal difficulties in overcoming the deficit of public health education in different cultural settings.

The prevailing rate of these misconceptions in high-achieving students following conventional curricula (more than 40 percent still holding beliefs in viral infections) is however a more serious educational predicament in comparison with results of some international surveys. The identified finding could be related to cultural particularities of the Japanese healthcare setting, such as historical prescribing habits and population health communication, which should become the focus of educational interventions.

Our intervention effect in lowering viral misconceptions to 19.9 percent is similar to the published outcomes of intensive antimicrobial stewardship training programs in other nations. This indicates that educational interventions which are designed well can meet international standards of competency development even against the current curriculum limitations.

Competently, our results in drug identification (81-95 percent identification rates) are higher than some of the international researches which reveals specific strengths related to Japanese pharmaceutical education methods of developing pharmacological knowledge. This observation implies the possibilities of cross-nation cooperation and experience exchange in the field of effective methods of teaching drug recognition and classification.

5.Conclusion and Future work

The overall findings of this excessive study has provided strong evidence that specifically designed antimicrobial stewardship education is capable of fundamentally changing the knowledge/attitudes/professional competencies of pharmacy students in a manner that is qualitatively different and significantly beyond the usual curricular interventions. The observed dramatic changes in all of the areas of assessment, ranging fron the fundamental pharmacological knowledge to the advanced clinical reasoning skills, show that properly crafted educational interventions can produce transformative learning results that previously have been believed to take years of clinical practice to achieve.

The extent of correction of misconceptions that our 90-minute intervention produced, especially the decreasing viral infection beliefs by 45 percent to 19.9 percent, is a paradigm shift in the effectiveness of educational interventions that challenges the traditional notion about curriculum design and delivery. These results have implications that the quality and specificity of educational interventions are perhaps more critical than their duration or intensity as long as they are highly professionally conceived and placed strategically within established educational parameters.

Professional Practice implications and Public Health Implications

The improvements in knowledge and attitudes reported in this research have an immense ramification on the future practice of pharmaceuticals and the health outcomes of the populations. The graduates with competencies in improved antimicrobial stewardship will become important liaisons between the prescribing doctors and patients and may potentially block thousands of inappropriate antimicrobial prescriptions during their employment life. Combined with the enhanced ability to counsel patients regarding their medications, thanks in large part to an improved understanding of the differences between viral and bacterial infections, these graduates can look forward to making a positive contribution to national campaigns to prevent antimicrobial resistance.

The equal public health benefits are reflected in the attitude of the medication compliance behaviors and disposal behaviors. By modeling the correct behaviors related to antimicrobial use and effectively counseling patients on the correct methods of managing their medication, pharmacists can effect changes in community-wide practices that produce multiplier effects that make the education investments go much further than the individual practitioners.

EICR Framework of Educational Innovation and Curricular Reform

The results of our study can serve as the solid evidence base to systematically reform the antimicrobial education in Japanese pharmacy curricula and can be used as helpful insights in international efforts to improve education. The illustrated success of focused interventions implicates that comparatively small alterations to the curriculum; carefully timed and skillfully executed might effectuate enormous change in graduate competence and population health preparedness.

Dispersing antimicrobial stewardship principles across the pharmacy education curriculum, as opposed to concentrating them within specific courses, can become one of the key approaches to optimizing the educational experience. This curriculum conforms to modern educational theory which suggests a spiral curriculum design and repetition of exposure to basic concepts in more complex clinical situations.

Faculty Development and Institutional Capacity Building

Our intervention, administered by a board-certified antimicrobial stewardship specialist, is a success that highlights the paramount value of faculty expertise as a means to attain transformative education outcomes. The fact that there is a national lack of eligible teachers qualified in clinical infectious diseases is another major obstacle in expanding these educational gains throughout Japanese pharmacy schools.

Heavy faculty development, with intense training in both the principles of antimicrobial stewardship and novel methods of pedagogy, becomes a key requirement and precursor to systematic education change. Such investments may be returned many times over in the competency of our graduates, contribution to the health of the population, and quality of professional practice.

Contributions to Research and Methodology Developments

The study is the initial attempt to critically evaluate the efficacy of antimicrobial stewardship education in the Japanese pharmaceutical training system and offers methodological breakthroughs that can be used in educational research across a variety of healthcare professionals. The targeted intervention comparison within multi-cohort, longitudinal design provides the strong structure of educational innovation evaluation that is also able to control the effects of time and cohort-specific variables.

Combined knowledge assessment, attitudinal evaluation, and analysis of clinical experience offer a holistic model of competency assessment that goes beyond the scope of the customary testing methods. This whole-person assessment system can provide an excellent hint to further educational studies that need to analyze the complicated development of professional competencies.

International Collaboration Opportunities and Global Implications

Knowledge gaps and educational issues described in this study are probably relevant to international systems of pharmacy education, as the threat of antimicrobial resistance is global, and the historical trends of inappropriate prescribing are similar. We have shown that multinational cooperation in the development and dissemination of successful educational interventions may speed up the processes of achieving better antimicrobial stewardship competency rates on the global level.

The teaching methods illustrated in this research study provide scalable solutions, which may be improved to suit different cultural and health care settings without compromising their essential efficiency. These results could be exploited by international collaborations dealing with faculty training, curriculum exchange, and outcome evaluation to make improvements in the quality of pharmaceutical education worldwide.

Acknowledgement: Nil

Conflicts of interest

The authors have no conflicts of interest to declare

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