

Original Article



Developing Core Elements and Checklist Items for Implementing Antimicrobial Stewardship Programs in Korean General Hospitals: A Modified Delphi Survey

Hae Suk Cheong ¹, Kyung-Hwa Park ², Bongyoung Kim ³,
Byung Wook Eun ⁴, Hyung-sook Kim ⁵, Yong Chan Kim ⁶, Hyukmin Lee ⁷,
Su Jin Jeong ⁶, Chisook Moon ⁸, Shin-Woo Kim ⁹, Young Kyung Yoon ¹⁰,
In Sun Hwang ¹¹, Choon-Seon Park ¹², Mi Suk Lee ¹³, Hong Bin Kim ¹⁴,
Ji-Yeon Shin ¹⁵, and Ki Tae Kwon ¹⁶

¹Division of Infectious Diseases, Department of Internal Medicine, Kangbuk Samsung Hospital, Sungkyunkwan University School of Medicine, Seoul, Korea

²Department of Infectious Diseases, Chonnam National University Medical School, Gwangju, Korea

³Department of Internal Medicine, Hanyang University College of Medicine, Seoul, Korea

⁴Department of Pediatrics, Nowon Eulji University Hospital, Seoul, Korea

⁵Department of Pharmacy, Seoul National University Bundang Hospital, Seongnam, Korea

⁶Division of Infectious Diseases, Department of Internal Medicine, Yonsei University College of Medicine, Seoul, Korea

⁷Department of Laboratory Medicine, Yonsei University College of Medicine, Seoul, Korea

⁸Division of Infectious Diseases, Department of Internal Medicine, Inje University College of Medicine, Busan, Korea

⁹Department of Internal Medicine, School of Medicine, Kyungpook National University, Daegu, Korea

¹⁰Division of Infectious Diseases, Department of Internal Medicine, Korea University College of Medicine, Seoul, Korea

¹¹Korea Institute for Healthcare Accreditation, Seoul, Korea

¹²Health Insurance Review and Assessment Research Institute, Health Insurance Review and Assessment Service, Wonju, Korea

¹³Division of Infectious Diseases, Department of Internal Medicine, Kyung Hee University College of Medicine, Kyung Hee University Hospital, Seoul, Korea

¹⁴Department of Internal Medicine, Seoul National University Bundang Hospital, Seoul National University College of Medicine, Seongnam, Korea

¹⁵Department of Preventive Medicine, School of Medicine, Kyungpook National University, Daegu, Korea

¹⁶Division of Infectious Diseases, Department of Internal Medicine, Kyungpook National University Chilgok Hospital, School of Medicine, Kyungpook National University, Daegu, Korea

Open Access

ABSTRACT

Background: Antimicrobial stewardship programs (ASPs) aim to optimize antimicrobial use by minimizing the spread of antimicrobial resistance. The core elements for implementing ASPs in healthcare facilities have been developed by the World Health Organization, international research group and government agencies of various countries. However, to date, there is no documented core elements for implementation of ASP in Korea. This survey aimed to establish a national consensus on a set of core elements and their related checklist items for the implementation of ASPs in Korean general hospitals.

Received: Dec 4, 2022

Accepted: Dec 20, 2022

Published online: Feb 15, 2023

Corresponding Author:

Ki Tae Kwon, MD, PhD
Division of Infectious Diseases, Kyungpook National University Chilgok Hospital, 807 Hokuk-ro, Buk-gu, Daegu 41404, Korea.
Tel: +82-53-200-2616, Fax: +82-53-200-3862
Email: ktkwon@knu.ac.kr

Copyright © 2023 by The Korean Society of Infectious Diseases, Korean Society for Antimicrobial Therapy, and The Korean Society for AIDS

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<https://creativecommons.org/licenses/by-nc/4.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

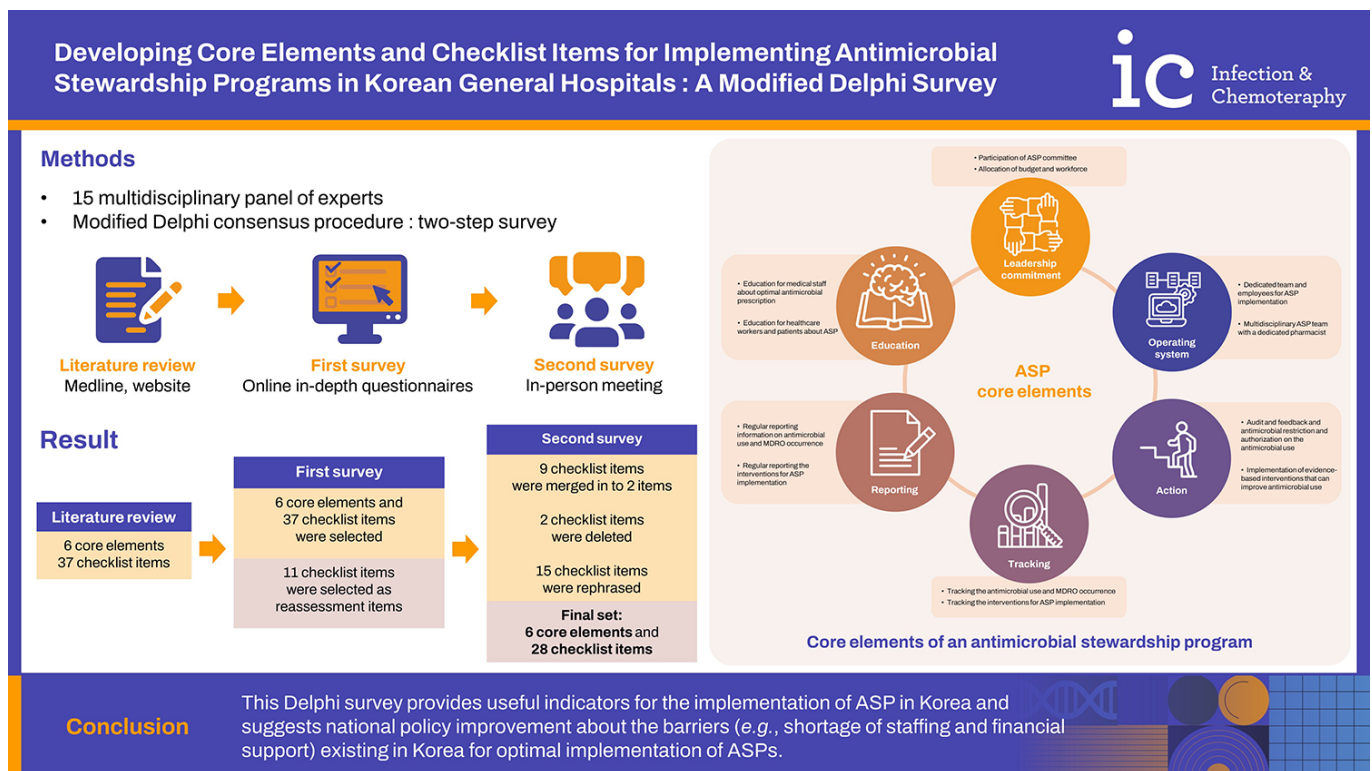
Materials and Methods: The survey was conducted from July 2022 to August 2022 by the Korean Society for Antimicrobial Therapy with support from the Korea Disease Control and Prevention Agency. A literature review was conducted by searching Medline and relevant websites to retrieve a list of core elements and checklist items. These core elements and checklist items were evaluated by a multidisciplinary panel of experts using a structured modified Delphi consensus procedure, using two-step survey included online in-depth questionnaires and in-person meeting.

Results: The literature review identified 6 core elements (Leadership commitment, Operating system, Action, Tracking, Reporting, and Education) and 37 related checklist items. Fifteen experts participated in the consensus procedures. Ultimately, all 6 core elements were retained, and 28 checklist items were proposed, all with $\geq 80\%$ agreement; in addition 9 items were merged into 2 items, 2 items were deleted, and 15 items were rephrased.

Conclusion: This Delphi survey provides useful indicators for the implementation of ASP in Korea and suggests national policy improvement about the barriers (e.g., shortage of staffing and financial support) existing in Korea for optimal implementation of ASPs.

Keywords: Anti-Infective agents; Drug resistance, Microbial; Multidisciplinary communication; Consensus

GRAPHICAL ABSTRACT



INTRODUCTION

Antimicrobial resistance (AMR) is a growing public health crisis and has emerged as one of the leading public health threats of the 21st century [1, 2]. Antimicrobial stewardship has been recommended as a key strategy for optimizing the use of antimicrobial agents and reducing the global threat of AMR [3]. The advocacy of

antimicrobial stewardship program (ASP) was already on the national and international agenda and several collaborative groups in North America, Europe and Australia have identified core elements considered essential for successful ASP through a consensual approach [4, 5]. In Korea, the government-led AMR management policy has been promoted since 2016 [6, 7]. The Second National Action Plan on AMR (2021 - 2025)

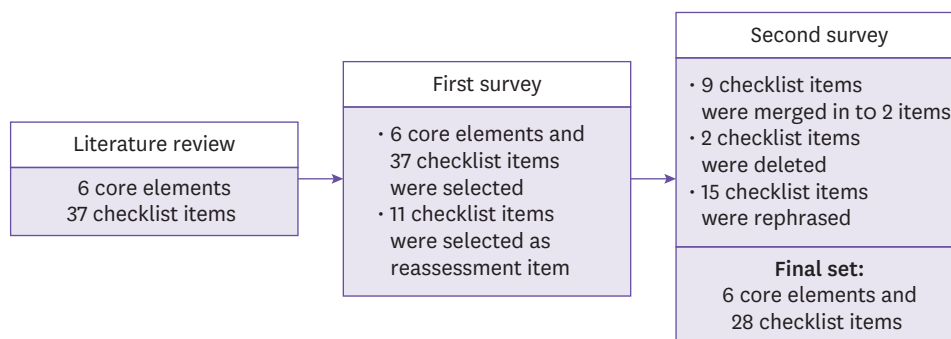


Figure 1. The Delphi consensus procedure: flow chart.

is being implemented currently, and the establishment of ASP in domestic healthcare institutions was suggested as a key strategy for overcoming AMR. Thus, the first Korean ASP guidelines were published in 2021 [8]. The next step includes developing ASP core elements suitable for domestic situations, and this step needs to be directly applied at Korean medical facilities [9, 10]. This study covers the contents of the consensus process for the article “Core Elements for Implementing ASP in Korean General Hospitals” published previously in *Infection & Chemotherapy*[11]. The purpose of this survey was to identify existing core elements for ASP and to provide national consensus on a set of core elements and their related checklist items for the implementation of ASPs in Korean general hospitals.

MATERIALS AND METHODS

1. Convening the expert panel and literature review

We assembled a panel of 15 experts (all the other co-authors) (Table 1). These experts had diverse content expertise (e.g., infectious disease physician, pharmacists, clinical microbiologists and administrators), and they represented ASPs at various stages of implementation to ensure the most generalizable and feasible representation. A systematic literature review was conducted to retrieve a list of core elements and their related checklist items. Seven researchers performed

Table 1. Expert panel details

Expert panel	N = 15
Infectious diseases, adult	10
Infectious diseases, pediatrics	1
Pharmacy	1
Clinical microbiology	1
Administration on Health Insurance Review and Assessment Service	1
Administration on Korean Institute for Healthcare Accreditation	1

a narrative literature review of PubMed and the search strategy involved: (1) antibiotics or antimicrobials, (2) stewardship, and (3) review or guidelines for core elements or checklist, in addition to a website search for determining existing core elements for ASP.

2. Ethics statement

This study is not project to ethical review as it does not involve interaction or intervention with human subjects and does not involve access to identifiable personal information.

3. Delphi process

The list of core elements and checklist items obtained based on the literature review and the website search was presented to the panel of 15 experts for modified Delphi consensus procedure [5]. This survey was conducted by the dividing the procedure into rounds 1 and 2 (Fig. 1).

In the first round, each expert panel filled individually questionnaire responses through online questionnaires. There was no discussion between the panels. Subsequently, the agree/disagree option for core elements and checklist items was checked. A comment box was provided for each item, and “opinion on item” and “opinion on rephrasing” were described. For the evaluation, the item was selected when the agreement was $\geq 80\%$ (≥ 12 experts), and when the agreement was 70 - 79% (11 experts), it was classified as an item to be re-evaluated in the second round. If the agreement was $< 70\%$ (< 11 experts), the item was rejected. The expert panel was asked to propose new items for further evaluation; in cases of newly proposed items, if ≥ 3 panels made similar proposals, the items were included in the second round of the review. The second round was conducted as a combination of face-to-face meeting and video conference if in-person meeting was inconvenient in order to reach a decision. Each panel of experts provided a score sheet showing the distribution of responses from all 15 experts and their own responses to each

item. The facilitator summarized and informed about the items that were well agreed or disagreed among the panels. Each panel provided their opinion on the items on which they disagreed, and the panel was given time to reassess each item. A clear distinction was made for the disagreed items to determine whether they were “really” different opinions or “artificial” disagreements caused by a deviation in the understanding of the item. Finally, evaluation and consensus were performed for newly added items, items undergoing re-evaluation, and best phrasing. If a majority of experts agreed, the corresponding phrasing was chosen. The facilitator did not artificially try to agree with the consensus.

RESULTS

Previous research such as ASP guidelines and recent papers were reviewed. In addition, through analysis of ASP operation cases such as Australia, United States of America,

Canada, United Kingdom, and Japan, and 6 core elements were selected and 37 checklist items were developed.

1. Round 1

Regarding the first 6 core elements and 37 checklist items, the consent of $\geq 80\%$ (12 people), which is presented as the initial consent standard, was achieved for all elements and items. However, we decided to re-evaluate 11 checklist items by combining items on each of the core elements that were agreed by only 13 people or items with ≥ 2 opinions as well as opinions on rephrasing (Table 2).

2. Round 2

The second round involved both face-to-face and online meetings. The opinions on the checklist items with different opinions were heard one-by-one, and each panel was given time to re-evaluate (Table 3). All 3 checklists of the core elements of ‘leadership commitment’ were rephrased. Among the core elements of ‘operating system’, checklist number 3 was deleted because it could

Table 2. Results of the Delphi survey, round 1

Core elements	Round 1	Agreement	Conclusion
Leadership commitment	1. There are regulations to operate the ASP committee, and hospital leadership must regularly hold and participate in the committee meetings. - Description: The committee includes medical staff other than those in ASP, which includes intensive care, medical, and surgical staff.	14/15	Accepted
	2. Hospital leadership allocates the budget and workforce required to conduct ASP.	15/15	Accepted
	3. Hospital leadership must establish ASP as the primary goal of the facility and include it among the key management indicators.	14/15	Accepted
Operating system	1. There are department as well as dedicated employees and teams that implement ASP with regulations for the individual roles and ASP procedures.	15/15	Accepted
	2. The dedicated team that conducts ASP should be a multidisciplinary team involving physicians, pharmacists, nurses, microbiologists, infection control experts, and information technology experts.	14/15	Accepted
	3. The working hours of the dedicated team shall be stipulated.	12/15	Accepted
	4. There must be a leader responsible for the operation and results of ASPs activities. - Description: The leader responsible for operating ASPs activities must be specialists in infectious diseases or pediatric infectious disease or a clinician with at least 3 years of experience in prescribing antimicrobials with ASP training.	13/15	Accepted
	5. There is a dedicated pharmacist who has completed ASP training and participates in its activities.	15/15	Accepted
Action	1. Prospective audit with feedback (back-end program) program on the use of antimicrobials is under implementation. - Description: Handshake stewardship, antimicrobials management guidelines, prescription review, feedback, etc.	14/15	Accepted
	2. Antimicrobial restriction and preauthorization (front-end program) of prescription for specific antimicrobials is under implementation.	14/15	Accepted
	3. An antimicrobial prescription form or a computerized antimicrobial prescription system is being established for the prescription of recommended antimicrobials based on the guidelines. - Description: Selection of appropriate antimicrobial agent, antimicrobial dosage, duration of treatment, prescription support for antimicrobial resistance, etc.	14/15	Accepted
	4. There is a clinical decision support system that encourages the empirical antimicrobial selection based on local antimicrobial susceptibility data or approved antimicrobial prescription guidelines for common infectious diseases.	15/15	Accepted

(continued to the next page)

Table 2. (Continued) to the next page) Results of the Delphi survey, round 1

Core elements	Round 1	Agreement	Conclusion
	5. There are specific interventions related to the optimal use of antimicrobials for major infectious diseases.	13/15	Accepted
	6. There is a program that supports minimizing antimicrobial combination therapy, antimicrobial de-escalation, optimal duration of treatment, or changing intravenous antimicrobials to oral antimicrobials.	15/15	Accepted
	7. Therapeutic drug monitoring is being utilized.	15/15	Accepted
	8. There is a rapid reporting of microbiologic results or a selective antimicrobial sensitivity built on the collaboration between the ASP team and the clinical microbiology Laboratory.	15/15	Accepted
Tracking	1. Through participation in KONAS, the use of antimicrobials in the medical facility is regularly monitored.	13/15	Accepted
	2. The antimicrobial use in the medical facility is regularly monitored using the facility's own computerized system.	15/15	Accepted
	3. The occurrence of six multi-drug resistant organisms (MRSA, VISA/VRSA, VRE, MRAB, MRPA, and CRE) included in healthcare-associated infections is tracked regularly (at least once in each quarter).	15/15	Accepted
	4. CDI occurrence is tracked regularly.	14/15	Accepted
	5. Antimicrobial susceptibility results for frequently isolated bacteria are tracked regularly.	15/15	Accepted
	6. The occurrence of antimicrobial adverse events is tracked regularly.	14/15	Accepted
	7. The acceptance of recommendations based on the prospective audit with feedback (back-end program) program is tracked regularly.	14/15	Accepted
	8. The degree of restriction/approval of antimicrobials included in the antimicrobial restriction and preauthorization (front-end program) of prescription for specific antimicrobials is tracked regularly.	14/15	Accepted
	9. The appropriateness of antimicrobial prescription (antimicrobials selection based on antimicrobial susceptibility to causative microorganisms and restriction on prescription of antimicrobials with overlapping spectrum or drug-drug interactions) is tracked regularly.	15/15	Accepted
	10. Regular tracking is conducted to determine whether the prescribed antimicrobials are being administered at optimal dose based on body weight and renal function.	15/15	Accepted
	11. Regular tracking is conducted to determine whether the prescribed antimicrobials comply with the institution's antimicrobial treatment guidelines for infectious diseases.	13/15	Accepted
	12. Regular tracking is conducted to ensure that surgical prophylactic use of antimicrobials are being administered appropriately.	15/15	Accepted
Reporting	1. The information on antimicrobial use (changes in dosage and prescription patterns based on ASP) is reported to the hospital leadership and the ASP committee and is shared with all employees. - Description: ASP implementation in a specific units (emergency room, intensive care unit, and units of frequent prescription of antimicrobials) and specific infectious diseases.	15/15	Accepted
	2. The information on antimicrobial resistance is regularly reported and shared with facility's employees.	14/15	Accepted
	3. The compliance of antimicrobials prescribed to individuals or groups based on the medical facility's guidelines for the treatment of infectious diseases is also shared.	13/15	Accepted
	4. The information on antimicrobials included in antimicrobial restriction and preauthorization is shared with prescribing medical staffs.	14/15	Accepted
	5. The adherence to recommendations by prospective audit with feedback (back-end program) program is shared with prescribing medical staffs.	15/15	Accepted
Education	1. Regular education on clinical practice guideline or antimicrobial treatment guidelines is provided to ensure proper antimicrobial prescription by medical staffs.	15/15	Accepted
	2. Regular ASP education is provided to the hospital leadership and healthcare workers.	15/15	Accepted
	3. Regular education on collection (blood culture, etc.), transport, management, and results interpretation for clinical specimen is provided to medical staffs.	15/15	Accepted
	4. Promotion and education on ASP are provided for patients and their caregivers to allow them to speak up for the appropriate use of antimicrobials.	12/15	Accepted

ASP, antimicrobial stewardship program; CDI, *Clostridioides difficile* infection; KONAS, Korea National Antimicrobial Use Analysis System; MRSA, methicillin-resistant *Staphylococcus aureus*; VISA/VRSA, vancomycin-intermediate/resistant *Staphylococcus aureus*; VRE, vancomycin-resistant *Enterococci*; MRAB, multidrug-resistant *Acinetobacter baumannii*; MRPA, multidrug-resistant *Pseudomonas aeruginosa*; CRE, carbapenem-resistant *Enterobacterales*.

Table 3. The Delphi survey, round 2

Core elements	Statement	Consensus
Leadership commitment		
1	<ul style="list-style-type: none"> It is necessary to clearly state that ASP is feasible only when hospital leadership participates in the committee. Rather than discuss the structure of the committee, it should be structured as a committee that can be operated well in practice. It is better to describe the content of the explanation as an example in the text rather than in the checklist. 	Rephrased
2	<ul style="list-style-type: none"> The feasibility of allocating dedicated employees should be considered. 	Rephrased
3	<ul style="list-style-type: none"> It means that the performance of ASP is continuously managed. 	Rephrased
Operating system		
1	<ul style="list-style-type: none"> It is agreed to assign a dedicated employees to the ASP team. If the dedicated working hours of dedicated employees are set mechanically, there is a problem that non-specialists receive formal training and do not perform actual tasks properly. Therefore, a system in which the dedicated employees performing actual tasks can receive legitimate economic compensation should be established, and policies should be implemented to appoint professional personnel as dedicated personnel in the future. There is a problem that the work is overloaded when the ASP work is entrusted to an existing department; therefore, a separate dedicated team and employees must be appointed. 	
2	<ul style="list-style-type: none"> The suggested professional manpower may be insufficient depending on the hospital, so additional explanations for essential members are required. The focus should be on the multidisciplinary nature of the team rather than each member of the dedicated team. 	Rephrased
3	<ul style="list-style-type: none"> If there are regulations regarding the dedicated team, the part about working hour regulation should be deleted. 	Deleted
4	<ul style="list-style-type: none"> An agreement regarding the qualifications of the leader is necessary. As standards for "antimicrobial expert certification education" are yet to be established in Korea, requirements for completion of education should be added in the future. It is controversial of the leader is only a doctor who has completed relevant training. Hence, the leader must be infectious disease specialist or a pediatric infectious disease, or an operating team who can take the responsibility for the results. 	Rephrased
5	<ul style="list-style-type: none"> Considering the hospital's pharmacist manpower, it is practically difficult to assign a dedicated pharmacist who do not perform other works. Therefore, it is necessary to set the working time during which the dedicated pharmacist needs to perform ASP related tasks in the future. It is difficult to conclude that all pharmacists have expertise in ASP. Therefore, an ASP dedicated pharmacists require a separate training course, and it is appropriate to have a pharmacist with 'qualification requirements' to be recognized as an expert to conduct ASP. 	
Action		
1	<ul style="list-style-type: none"> In most hospitals in Korea, it is currently difficult to apply prospective audit and feedbacks in practice. It would be better to recommend various intervention activities for audit and feedback on the use of antimicrobials. 	Rephrased
2	<ul style="list-style-type: none"> Preauthorization of prescription for antimicrobials is currently difficult owing to the manpower-related issues in most hospitals in Korea. The compulsory preauthorization of prescription can directly cause the violation of right to treatment and lead to unnecessary conflicts with other departments; therefore training and cooperation between departments can become difficult. 	Rephrased
3	<ul style="list-style-type: none"> The establishment of antimicrobial prescription form or a computerized antimicrobial prescription system is one of the ASP implementation, and medical facilities can choose to apply it based on their current situations. Examples of antimicrobial prescription forms should be added. 	Rephrased
4	<ul style="list-style-type: none"> The term 'clinical decision support system for antimicrobial selection" is vague and ambiguous. Establishment and revision of a computerized clinical decision support system by medical facility according to their guidelines is also difficult. 	Merged into 3 - 3

(continued to the next page)

Table 3. (Continued) The Delphi survey, round 2

Core elements	Statement	Consensus
5	<ul style="list-style-type: none"> According to the scientific evidence for the prescription of antimicrobials, guidelines for antimicrobial prescription at the facility level should be prioritized. 	Merge 3 - 5 to 3 - 8 into one item
6	<ul style="list-style-type: none"> Intervention activities for antimicrobials for all listed diseases are practically difficult; thus, it is necessary to reduce the number of activities depending on the facility's situation. 	
7	<ul style="list-style-type: none"> As simultaneous implementations of all presented items are not feasible, presenting them as accompanying intervention activities is preferable. 	Merge 3 - 5 to 3 - 8 into one item
8	<ul style="list-style-type: none"> Presenting the items of the accompanying intervention activities depending on the capabilities of the medical facilities would also be preferable. 	
	<ul style="list-style-type: none"> As immediate implementation at all medical facilities is not feasible, it would be preferable to present the item as one of the accompanying intervention activities. It would also be preferable to provide an explanation or specific example for the activities. 	Rephrased and merge 3 - 5 to 3 - 8 into one item
Tracking		
1	<ul style="list-style-type: none"> Participation in KONAS is limited depending on the size and medical resources of a medical facility, mandatory registration is unfeasible. Because KONAS should be linked to the hospital's monitoring investigation system, its applicability to small- and medium-sized hospitals must be reviewed. 	Deleted
2	<ul style="list-style-type: none"> As some hospitals do not have a computerized system for the use of antimicrobials, the use of their own hospital system is allowed. Both antimicrobials use and prescription patterns must be managed. 	Rephrased
3	<ul style="list-style-type: none"> This activity is naturally implemented when the infection control team is in the medical facility. 	
4	<ul style="list-style-type: none"> Distinguishing between children and adults is necessary. Distinguishing between community acquired and hospital acquired origin is necessary. 	Rephrased
5	<ul style="list-style-type: none"> For clinically important bacteria, it is necessary to post the current status of the bacteria's antimicrobial susceptibility even if the incidence is low. 	
6	<ul style="list-style-type: none"> It is necessary to check whether the antimicrobial adverse event reporting system is being actively used. The term "side effect" has been revised to "adverse event." Adverse reactions should be considered in the scope of the Drug Safety Management Center. 	Rephrased
7	<ul style="list-style-type: none"> Prospective audit with feedback is often unfeasible. 	
8	<ul style="list-style-type: none"> Preauthorization of antimicrobials use is difficult to implement in most hospital. 	Merge 4 - 9 to 4 - 12 into one item
9	<ul style="list-style-type: none"> It would be good to suggest an observation period. 	
10	<ul style="list-style-type: none"> It is recommended to change to 'whether antimicrobials are being administered in an appropriate dose for patients with severe obesity or end-stage renal failure'. 	Merge 4 - 9 to 4 - 12 into one item
11	<ul style="list-style-type: none"> The evaluation of whether the treatment guidelines are being followed must involve many variables, and as it requires the intervention of specialist, the continuation of the activities by most hospitals is not feasible owing to manpower-related problems. The existence of treatment guidelines in the medical facilities should be a prerequisite. 	
12	<ul style="list-style-type: none"> Guidelines should be presented together with antimicrobial prescription adequacy. 	Merge 4 - 9 to 4 - 12 into one item
Reporting		
1	<ul style="list-style-type: none"> Information on antimicrobials use shall be shared with relevant employees. 	Rephrased
2	<ul style="list-style-type: none"> Reporting and sharing shall be carried out according to the situations of the medical facilities rather than periodically. 	Rephrased
3	<ul style="list-style-type: none"> The problem presented in item 11 of core elements 'Tracking' still exists. 	Rephrased
4	<ul style="list-style-type: none"> Implementation of preauthorization of antimicrobial prescription is unfeasible. 	
5	<ul style="list-style-type: none"> The problem presented in item 8 of core elements 'Tracking' still exists. 	Rephrased
Education		
4	<ul style="list-style-type: none"> As educating healthcare workers about ASP may be overwhelming, the education of patients and caregiver should be discussed in detail. 	

ASP, antimicrobial stewardship program; KONAS, Korea National Antimicrobial Use Analysis System.

be included in the regulation of item 1, and items 1 and 4 were rephrased. Checklist item numbers 4 - 8 of the core elements of 'intervention' were difficult to implement simultaneously in all hospitals; therefore, they were grouped into one checklist item and presented as sub-items and checklist item numbers 1 - 3 were rephrased. Among the core elements of 'tracking', checklist item number 1 was deleted, and items 2, 6, and 7 were rephrased. In addition, the checklist item numbers 9 - 12 were combined into one and presented as sub-items for the same reason as the core element 'action'. The core elements of 'reporting' were rephrased, except for checklist number 3. Finally, 6 core elements and 28 checklist items were selected (Table 4).

DISCUSSION

This paper demonstrates the core elements and checklist item development process for ASP implementation at domestic general hospitals based on the structured consensus procedure. In Korea, ASP guidelines have been recently published for the first time [8]. In the absence of previous domestic research on ASP implementation, the core elements and checklist items were first written based on the results of other countries' studies that were already implementing ASP. In addition, to ensure the establishment of ASP in Korea, it is necessary to select the most effective and feasible items in Korea; thus, experts from various fields were invited to join the expert panel for this agreement procedure. In particular, to develop ASP core elements and their related checklist items to be established in Korea, agreement between policy makers and healthcare institution certification bodies is important; thus, experts from these fields also participated in the present study.

Implementing ASP in medical facilities is one of the aspects of a comprehensive One Health strategy needed to solve the problem of AMR [3]. Successful establishment of ASP in Korean hospitals is impossible without the strong support and encouragement of national policy makers and senior executives, and it is an important prerequisite for each medical facility to have professional manpower who can properly implement ASP. However, in Korea, there is a shortage of infectious diseases specialists and trained pharmacists who can take the responsibility of operating ASPs in Korea. As a result of estimating the human resource required for the ASP in Korean hospitals, the personnel requirement was calculated as 1.20 full-time equivalents (FTEs) (interquartile range [IQR]: 1.02 - 1.38) per 100 beds and 2.28 FTEs (IQR: 1.93 - 2.62) per 100 patients who received antimicrobial therapy. However, in a nationwide survey

of 84 hospitals with ≥ 500 -beds, 94% of hospitals had no FTEs to implement ASP [12, 13]. In order to overcome this shortage, it is necessary to prepare a systematic support plan to promote experts who can operate ASP, and to develop and implement a systematic training process. In addition, for medical facilities to adopt ASP and have an operating system, such as a dedicated team or committee, and continuous implementation, financial support must be provided, for example, by introducing a financial support for ASP activities in the National Health Insurance. Also, it is necessary to activate publicity and education to increase the awareness and acceptance of ASP among the hospital leaderships and medical staffs who prescribe antimicrobials [14]. In Korea, medical facilities are about to introduce ASP in earnest, and the core elements and checklists for ASP confirmed by this survey need to be evaluated and revised regularly. It is believed that the modified Delphi survey method used in this study could be a useful tool in the future revision process.

This study has some limitations. First, the panel participating in the consensus procedure was intended to be multidisciplinary, but infectious disease physicians accounted for the majority of the people in the panel. Therefore, it is possible that the consensus process was biased toward the point of view of infectious disease physicians and thus the consensus might not consider hospitals other than those to which the panels belonged to. Second, as we attempted to include items that were applicable to various medical facilities, there is a possibility that the checklist items were rephrased with generalized content, and each item may be interpreted differently based on the facility's intention. This is an unavoidable limitation because the computer system, personnel, and organizational system of each hospital are different.

In conclusion, to the best of our knowledge, the core elements and checklist items of ASP were developed for the first time in Korea using this modified Delphi process, and these were written rationally for their immediate application in Korea. Moreover, we believe that the value of this survey has been further enhanced by the participation from experts in various fields. In the future, it is expected that each medical facility will conduct studies for effectiveness on the use of antimicrobials obtained through the implementation of the ASP core elements and the related checklist items that have been developed in the study.

Table 4. Results of the Delphi survey, round 2

Core elements	Round 2
Leadership commitment	<ol style="list-style-type: none"> 1. Regulations to operate the ASP committee with the participation of hospital leadership are established, and regular meetings are held. 2. Hospital leadership allocates the budget and workforce necessary to implement the ASP. 3. Hospital leadership sets the implementation of the ASP as the priority goal of the facility and manages indicators to measure program performance.
Operating system	<ol style="list-style-type: none"> 1. There are departments as well as dedicated employees and teams that implement ASP with regulations for the individual roles and ASP procedures. 2. The dedicated team that conducts ASP should be a multidisciplinary team involving physicians, pharmacists, nurses, clinical microbiologists, infection control professionals, and information system professionals. 3. There should be a leader in charge of the operation of ASP. 4. There is a dedicated pharmacist who has completed ASP training and participates in its activities.
Action	<ol style="list-style-type: none"> 1. Audit and feedback on the use of antimicrobials are under implementation. 2. Antimicrobial restriction and authorization of prescription for specific antimicrobials are under implementation. 3. An antimicrobial prescription form or a computerized antimicrobial prescription system recommends and supports antimicrobial prescriptions based on ASP guidelines at medical facility. 4. Interventions for major infectious diseases or other supplementary ASP interventions are conducted. <ul style="list-style-type: none"> - Major infectious diseases include urinary tract infection, community-acquired pneumonia, bloodstream infections, and CDI. - Accompanying ASP interventions include minimizing antimicrobial combination therapy, antimicrobial de-escalation, recommending optimal duration of treatment, changing intravenous antimicrobials to oral antimicrobials, utilizing TDM for specific antimicrobials, and rapid reporting of microbiological results.
Tracking	<ol style="list-style-type: none"> 1. The use of antimicrobials within a medical facility is being tracked regularly. 2. The status of the occurrence of six multidrug-resistant organisms (MRSA, VISA/VRSA, VRE, MRAB, MRPA, and CRE), which are designated as communicable diseases in Korean are tracked regularly (at least once in each quarter). 3. The incidence of CDI is tracked regularly. 4. The antimicrobial susceptibility results for frequently isolated bacteria are tracked regularly. 5. The occurrence of antimicrobial adverse events is tracked regularly. 6. The acceptance of recommendations based on audit and feedback on the use of antimicrobials is tracked regularly. 7. The degree of approval of antimicrobial restriction and prescription authorization for specific antimicrobials are tracked regularly. 8. Interventions for major infectious diseases or other supplementary ASP interventions are tracked regularly. <ul style="list-style-type: none"> - Major infectious diseases include urinary tract infection, community-acquired pneumonia, bloodstream infections, and CDI. - Accompanying ASP interventions include minimizing antimicrobial combination therapy, antimicrobial de-escalation, recommending optimal duration of treatment, changing intravenous antimicrobials to oral antimicrobials, utilizing TDM for specific antimicrobials, and rapid reporting of microbiological results.
Reporting	<ol style="list-style-type: none"> 1. The information on antimicrobial use (changes in dosage and prescription patterns based on ASP) is reported to the hospital leadership and the ASP committee and shared with relevant employees. 2. The information on antimicrobial resistance is reported and shared. 3. The information on antimicrobial prescription by individuals or groups compliant with the medical facility's guidelines for the treatment of infectious diseases is reported and shared. 4. The information on antimicrobial restriction and prescription authorization for specific antimicrobials is shared with prescribing medical staffs. 5. The adherence to recommendations based on audit and feedback interventions on the use of antimicrobials is shared with prescribing medical staffs.
Education	<ol style="list-style-type: none"> 1. Regular education on clinical practice guideline or antimicrobial treatment guidelines is provided to ensure proper antimicrobial prescription by medical staffs. 2. Regular ASP education is provided to the hospital leadership and healthcare workers. 3. Regular education on collection (blood culture, etc.), transport, management, and results interpretation for clinical specimen is provided to medical staffs. 4. Promotion and education on ASP are provided for patients and their caregivers to allow them to speak up for the appropriate use of antimicrobials.

ASP, antimicrobial stewardship program; CDI, *Clostridioides difficile* infections; TDM, therapeutic drug monitoring; MRSA, methicillin-resistant *Staphylococcus aureus*; VISA/VRSA, vancomycin-intermediate/resistant *Staphylococcus aureus*; VRE, vancomycin-resistant *Enterococci*; MRAB, multidrug-resistant *Acinetobacter baumannii*; MRPA, multidrug-resistant *Pseudomonas aeruginosa*; CRE, carbapenem-resistant *Enterobacterales*.

ORCID iDs

Hae Suk Cheong 
<https://orcid.org/0000-0001-8702-1987>
 Kyung-Hwa Park 
<https://orcid.org/0000-0003-2836-6963>
 Bongyoung Kim 
<https://orcid.org/0000-0002-5029-6597>
 Byung Wook Eun 
<https://orcid.org/0000-0003-3147-9061>
 Hyung-sook Kim 
<https://orcid.org/0000-0002-6385-9619>
 Yong Chan Kim 
<https://orcid.org/0000-0001-5081-7906>
 Hyukmin Lee 
<https://orcid.org/0000-0002-8523-4126>
 Su Jin Jeong 
<https://orcid.org/0000-0003-4025-4542>
 Chisook Moon 
<https://orcid.org/0000-0002-9063-9312>
 Shin-Woo Kim 
<https://orcid.org/0000-0002-3755-8249>
 Young Kyung Yoon 
<https://orcid.org/0000-0001-8435-935X>
 In Sun Hwang 
<https://orcid.org/0000-0003-1965-615X>
 Choon-Seon Park 
<https://orcid.org/0000-0001-8298-0150>
 Mi Suk Lee 
<https://orcid.org/0000-0001-8951-5032>
 Hong Bin Kim 
<https://orcid.org/0000-0001-6262-372X>
 Ji-Yeon Shin 
<https://orcid.org/0000-0001-5434-0359>
 Ki Tae Kwon 
<https://orcid.org/0000-0003-4666-0672>

Funding

This research was supported by a fund (No. 2021-10-030) by Research of Korea Disease Control and Prevention Agency.

Conflict of Interest

BWE and HBK are editorial board of *Infect Chemother*; however, they did not involve in the peer reviewer selection, evaluation, and decision process of this article. Otherwise, no potential conflicts of interest relevant to this article was reported.

Author Contributions

Conceptualization: KTK, HSC, KP. Funding acquisition: KTK. Investigation: BK, CM, MSL, YKY, SJJ, YCK, BWE, HK, ISH, CP, HL. Methodology: KTK, JS. Supervision: HBK, SK, MSL. Writing - original draft: HSC. Writing - review & editing: HSC, KTK, KP, BK, BWE, HK, YCK, HL, SJJ, CM, SK, YKY. ISH, CP, MSL, HBK, JS.

REFERENCES

1. Antimicrobial Resistance Collaborators. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *Lancet* 2022;399:629-55.
[PUBMED](#) | [CROSSREF](#)
2. World Health Organization (WHO). Antimicrobial resistance. Available at: <https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance>. Accessed 19 October 2022.
3. Alliance for Health Policy and Systems Research (AHPSR). Global action plan on antimicrobial resistance. Available at: <https://ahpsr.who.int/publications/i/item/global-action-plan-on-antimicrobial-resistance>. Accessed 19 October 2022.

4. Charani E, Holmes A. Antibiotic stewardship-twenty years in the making. *Antibiotics (Basel)* 2019;8:7.
[PUBMED](#) | [CROSSREF](#)
5. Pulcini C, Binda F, Lamkang AS, Trett A, Charani E, Goff DA, Harbarth S, Hinrichsen SL, Levy-Hara G, Mendelson M, Nathwani D, Gunturu R, Singh S, Srinivasan A, Thamlikitkul V, Thursky K, Vlieghe E, Wertheim H, Zeng M, Gandra S, Laxminarayan R. Developing core elements and checklist items for global hospital antimicrobial stewardship programmes: a consensus approach. *Clin Microbiol Infect* 2019;25:20-5.
[PUBMED](#) | [CROSSREF](#)
6. Ryu S. The new Korean action plan for containment of antimicrobial resistance. *J Glob Antimicrob Resist* 2017;8:70-3.
[PUBMED](#) | [CROSSREF](#)
7. World Health Organization (WHO). Republic of Korea: Second national action plan on antimicrobial resistance 2021-2025 (Korean). Available at: <https://www.who.int/publications/m/item/republic-of-korea-second-national-action-plan-on-antimicrobial-resistance-2021-2025>. Accessed 10 February 2023.
8. Yoon YK, Kwon KT, Jeong SJ, Moon C, Kim B, Kiem S, Kim HS, Heo E, Kim SW; Korean Society for Antimicrobial Therapy; Korean Society of Infectious Diseases; Korean Society of Health-System Pharmacist. Guidelines on implementing antimicrobial stewardship programs in Korea. *Infect Chemother* 2021;53:617-59.
9. Hwang S, Kwon KT. Core elements for successful implementation of antimicrobial stewardship programs. *Infect Chemother* 2021;53:421-35.
[PUBMED](#) | [CROSSREF](#)
10. Kim HS, Park SY, Choi H, Park JY, Lee MS, Eun BW, Lee H, Choi JY, Kim HB, Jeong SJ, Uh Y, Kim B. Development of a roadmap for the antimicrobial usage monitoring system for medical institutions in Korea: a delphi study. *Infect Chemother* 2022;54:483-92.
[PUBMED](#) | [CROSSREF](#)
11. Cheong HS, Park KH, Kim HB, Kim SW, Kim B, Moon C, Lee MS, Yoon YK, Jeong SJ, Kim YC, Eun BW, Lee H, Shin JY, Kim HS, Hwang IS, Park CS, Kwon KT; Korean Society for Antimicrobial Therapy; Korean Society of Infectious Diseases; Korean Society for Healthcare-associated Infection Control and Prevention; Korean Society of Pediatric Infectious Diseases, The Korean Society of Health-system Pharmacists. Core elements for implementing antimicrobial stewardship programs in Korean general hospitals. *Infect Chemother* 2022;54:637-73.
[PUBMED](#) | [CROSSREF](#)
12. Park SY, Chang HH, Kim B, Moon C, Lee MS, Kim JY, Jung DS, Kim SW, Moon SM, Kim ES, Kim HB; for Korea Study Group For Antimicrobial Stewardship (KOSGAP). Human resources required for antimicrobial stewardship activities for hospitalized patients in Korea. *Infect Control Hosp Epidemiol* 2020;41:1429-35.
[PUBMED](#) | [CROSSREF](#)
13. Kim B, Lee MJ, Moon SM, Park SY, Song KH, Lee H, Park JS, Lee MS, Choi SM, Yeom JS, Kim JY, Kim CJ, Chang HH, Kim ES, Kim TH, Kim HB; Korea Study Group for Antimicrobial Stewardship (KOSGAP). Current status of antimicrobial stewardship programmes in Korean hospitals: results of a 2018 nationwide survey. *J Hosp Infect* 2020;104:172-80.
[PUBMED](#) | [CROSSREF](#)
14. Kwon KT. Implementation of antimicrobial stewardship programs. *J Korean Med Assoc* 2022;65:498-504.
[CROSSREF](#)