Journal of Global Antimicrobial Resistance 26 (2021) 180–187

Contents lists available at ScienceDirect

Journal of Global Antimicrobial Resistance

journal homepage: www.elsevier.com/locate/jgar

Status of antimicrobial stewardship programmes in Korean hospitals including small to medium-sized hospitals and the awareness and demands of physicians: a nationwide survey in 2020

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ARTICLE INFO

Article history:
Received 14 January 2021
Revised 26 May 2021
Accepted 3 June 2021
Available online 18 June 2021

Editor: G. L. Hara

Keywords:
Antibiotics
Stewardship
Resistance
Infectious diseases
Korea

ABSTRACT

Objectives: This study aimed to identify the status of antimicrobial stewardship programmes (ASPs) in small to medium-sized Korean hospitals as well as the awareness and demands about ASPs of physicians.

Methods: A questionnaire was designed based on a questionnaire from a previous nationwide survey in 2018 targeting large hospitals in Korea and modified to reflect the results of in-depth interviews with non-infectious diseases (IDs) physicians at secondary care hospitals. The survey targeted all hospitals with ≥150 beds in South Korea and was performed in May–June 2020. Only one ASP-associated physician per hospital participated in the survey.

Results: The survey response rate was 31.9% (217/680). ID specialists comprised the majority of medical personnel participating in ASPs in tertiary care hospitals. Conversely, in secondary and primary care hospitals there was no predominant medical personnel for ASPs and the median full-time equivalent was 0 for all types of medical personnel. Tertiary care hospitals, more than secondary and primary care hospitals, tended to perform ASP activities more actively. 'Workforce for ASPs', 'Establishment of healthcare

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https://doi.org/10.1016/j.jgar.2021.06.001

fees for ASPs' and 'Development of tools for ASPs' were the most important required support for ASP improvement.

Conclusion: The level of ASP establishment was more limited in primary care hospitals than in secondary and tertiary care hospitals in Korea. To improve ASPs in Korean hospitals, a supporting workforce and the establishment of a healthcare fee for ASPs appear to be necessary.

1. Introduction

Inappropriate antimicrobial use leads to ineffective treatment of patients with infections, increased antimicrobial-associated adverse effects, increased medical costs and the emergence of antimicrobial resistance (AMR) [1,2]. Unfortunately, the level of antimicrobial usage in Korea is higher than the average level among other Organisation for Economic Co-operation and Development (OECD) countries [3].

Antimicrobial stewardship programmes (ASPs) are a set of multidisciplinary activities focused on proper use of antimicrobials aiming to achieve optimal clinical outcomes, prevent adverse antimicrobial-associated effects, reduce hospital costs and prevent the development of AMR [4]. ASPs are a key strategy to cope with AMR since increased antimicrobial use enhances selective pressure on bacteria, which is closely linked to the emergence of AMR [5]. Furthermore, since several studies demonstrated the effectiveness of ASPs in various hospital settings, many countries have been encouraging their hospitals to establish ASPs [6–8].

Enhancing ASPs is a key component of the Korean National Action Plan on Antimicrobial Resistance 2016–2020 [9]. Furthermore, since 2018 the Korea Institute for Healthcare Accreditation requires that for accreditation, acute care hospitals should have management systems for antibiotics, such as antimicrobial management committees [10]. However, owing to the limited implementation of ASPs, the proportion of cases of inappropriate antimicrobial use in patients in Korean hospitals is reportedly 27.7% [11,12].

To improve appropriate use of antimicrobials and to reduce AMR, reinforcing and diversifying ASPs is necessary. We previously identified the national status of ASPs in large hospitals in 2006, 2012, 2015 and 2018, but a study regarding the status of ASPs in hospitals with medium to small size has not yet been conducted [12]. This study aimed to identify the status of ASPs in small to medium-sized Korean hospitals as well as the awareness and demands of ASPs by physicians.

2. Methods

2.1. Questionnaire design

In the initial phase of questionnaire development, in-depth interviews were conducted: two investigators (BK and HK) interviewed non-infectious diseases (IDs) physicians in charge of policies regarding the usage of antibiotics in three secondary care non-university-affiliated hospitals with 360–600 beds in Korea. The draft questionnaire, designed by one investigator (BK) based on a questionnaire from a previous nationwide survey and previous studies [12–15], was modified to reflect the 'Seven Core Elements of Hospital Antimicrobial Stewardship Programs' from the US Centers for Diseases Control and Prevention (CDC) and the results of in-depth interviews [16]. The other investigators reviewed the draft questionnaire, which was refined on the SurveyMonkey® platform (Supplement 1).

Items in the 'Awareness of ASPs' section were measured using a seven-point Likert scale. Higher scores implied that the respondent agreed, thought it necessary or thought it applicable. We considered questions with scores >4 as items that respondents agreed with, thought were necessary or thought were applicable. For items in 'Demand for establishing or expansion of ASPs in Korean hospitals', respondents determined the order of priority according to the importance of each factor. The factors were calculated using a priority weighting method (6, 5, 4, 3, 2 and 1 points for first, second, third, fourth, fifth and sixth places, respectively).

2.2. Definitions

Hospital types were defined according to the Korean healthcare delivery system [17]. Primary care hospitals have >30 beds and do not meet secondary and tertiary care hospitals' criteria. Secondary care hospitals have >100 beds, are referral centres for primary medical institutions, and operate nine mandatory departments, namely internal medicine, general surgery, paediatrics, obstetrics and gynaecology, radiology, anaesthesiology, laboratory medicine, psychiatry and odontology. Tertiary care hospitals have >500 beds, are referral centres for primary and secondary medical institutions, operate the aforementioned nine mandatory departments, and have a residents' training system for each department.

ID specialists were board-certified physicians for adult or paediatric infectious diseases in Korea.

2.3. Conducting the survey

The survey targeted 680 acute care hospitals with ≥ 150 beds (42 tertiary care hospitals, 320 secondary care hospitals and 318 primary care hospitals) that were registered in the Korea Disease Control and Prevention Agency (KCDC) database in December 2019. The first official letter containing the online survey link was forwarded to each hospital by the KCDC on 14 May 2020, and the second letter with similar content was sent by the Korean Hospital Association on 3 June 2020. The 5-week survey was conducted from 14 May 2020 to 17 June 2020. To ensure accuracy, the physicians in charge of antibiotic policies in the targeted hospitals were to respond. There were no rewards for completing the questionnaire. Only one questionnaire per hospital was administered.

2.4. Statistical analysis

Data were exported to Microsoft Excel® (Microsoft Corp., Redmond, WA, USA) using SurveyMonkey®. IBM SPSS Statistics for Windows v.26.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. To identify differences in the status of ASPs according to hospital type, categorical and continuous variables were analysed using χ^2 test or Fisher's exact test and one-way analysis of variance (ANOVA) test, respectively. A two-tailed P-value of <0.05 was considered statistically significant. To assess interhospital differences in medical personnel participating in ASPs, we used the

Table 1
Characteristics of hospitals and respondents in the study

Characteristic	Total (N = 217)	Tertiary care (N = 24)	Secondary care (N = 112)	Primary care (N = 81)	P-value
Specialty of the respondent [n (%)]					
Infectious diseases [a]	53 (24.4)	24 (100)	29 (25.9)	0 (0)	<0.001
Internal medicine (except ID subspecialty)	87 (40.1)	0 (0)	38 (33.9)	49 (60.5)	
Laboratory medicine	17 (7.8)	0 (0)	17 (15.2)	0 (0)	
Family medicine	7 (3.2)	0 (0)	3 (2.7)	4 (4.9)	
General surgery	10 (4.6)	0 (0)	4 (3.6)	6 (7.4)	
Psychiatry	9 (4.1)	0 (0)	1 (0.9)	8 (9.9)	
Orthopaediatrics	8 (3.7)	0 (0)	3 (2.7)	5 (6.2)	
Family medicine	7 (3.2)	0 (0)	3 (2.7)	4 (4.9)	
Paediatrics (except ID subspecialty)	5 (2.3)	0 (0)	4 (3.6)	1 (1.2)	
Others	14 (6.5)	0 (0)	10 (8.9)	4 (4.9)	
Hospital type, by educational system [n (%)]					
University-affiliated hospital	37 (17.1)	24 (100)	13 (11.6)	0 (0)	<0.001
Training hospital	54 (24.9)	0 (0)	51 (45.5)	3 (3.7)	
Non-training hospital	126 (58.1)	0 (0)	48 (42.9)	78 (96.3)	
Inpatient bed capacity [n (%)]					
150–499	170 (78.3)	0 (0)	89 (79.5)	81 (100)	<0.001
500–999	37 (17.1)	14 (58.3)	23 (20.5)	0 (0)	
≥1000	10 (4.6)	10 (41.7)	0 (0)	0 (0)	
No. of ICU beds [n (%)]					
0	93 (42.9)	0 (0)	22 (19.6)	71 (87.7)	<0.001
1–14	40 (18.4)	0 (0)	32 (28.6)	8 (9.9)	
15–29	47 (21.7)	6 (25.0)	41 (36.6)	0 (0)	
≥30	37 (17.1)	18 (75.0)	17 (15.2)	2 (2.5)	
Human resources [n (%)]					
Doctors [b]					
<50	145 (67.4)	0 (0)	64 (57.7)	81 (100)	<0.001
50–99	22 (10.2)	0 (0)	22 (19.8)	0 (0)	
≥100	48 (22.3)	23 (100)	25 (22.5)	0 (0)	
Pharmacists [b]					
<5	147 (68.4)	0 (0)	68 (61.3)	79 (97.5)	<0.001
5–9	18 (8.4)	0 (0)	16 (14.4)	2 (2.5)	
≥10	50 (23.3)	23 (100)	27 (24.3)	0 (0)	
Nurses [b]					
<100	92 (42.8)	0 (0)	24 (21.6)	68 (84.0)	<0.001
100–199	51 (23.7)	0 (0)	40 (36.0)	11 (13.6)	
≥200	72 (33.5)	23 (100)	47 (42.3)	2 (2.5)	
Staff in IT department [b]					
0	17 (7.9)	0 (0)	1 (0.9)	16 (19.8)	<0.001
1–4	133 (61.9)	0 (0)	69 (62.2)	64 (79.0)	
≥5	65 (30.2)	23 (100)	41 (36.9)	1 (1.2)	
Adult ID specialist					
0	163 (75.1)	0 (0)	82 (73.2)	81 (100)	<0.001
1–2	36 (16.6)	11 (45.8)	25 (22.3)	0 (0)	
≥3	18 (8.3)	13 (54.2)	5 (4.5)	0 (0)	
Paediatric ID specialist					
0	188 (86.6)	11 (45.8)	98 (87.5)	79 (97.5)	<0.001
1	24 (11.1)	9 (37.5)	13 (11.6)	2 (2.5)	
≥2	5 (2.3)	4 (16.7)	1 (0.9)	0 (0)	
Internal medicine specialist (except ID subspecialty)					
<5	101 (46.5)	0 (0)	26 (23.2)	75 (92.6)	<0.001
5–9	45 (20.7)	0 (0)	39 (34.8)	6 (7.4)	
≥10	71 (32.7)	24 (100)	47 (42.0)	0 (0)	

ID, infectious diseases; ICU, intensive care unit; IT, information technology.
[a] Includes neurology, neurosurgery, obstetrics and gynaecology, rehabilitation, emergency medicine, urology, preventive medicine, pathology, chest surgery and anaesthesiology.
[b] Two hospitals (one each for tertiary care hospital and secondary care hospital) did not answer this question.

Kruskal–Wallis test with the Bonferroni correction, and considered a P-value of <0.016 as statistically significant.

2.5. Ethical statement

The study protocol was approved by the institutional review board of Hanyang University Seoul Hospital, and the requirement for written informed consent was waived.

3. Results

3.1. Characteristics of hospitals and respondents in the study

Of the 680 hospitals surveyed, 217 (31.9%) responded to the online-based survey. The proportions of tertiary, secondary and primary care hospitals were 11.1% (24/217), 51.6% (112/217) and 37.3% (81/217), respectively. The response rates by hospital type was: tertiary care hospitals, 57.1% (24/42); secondary care hospitals, 35.0% (112/320); and primary care hospitals, 25.5% (81/318).

Table 1 shows the overall characteristics of the hospitals and respondents in this study. Most respondents were ID specialists (24.4%) and non-ID internal medicine specialists (40.1%). Among the hospitals, 58.1% (126/217) were non-training hospitals, 78.3% (170/217) had <500 beds and 42.9% (93/217) did not operate an intensive care unit.

All tertiary care hospitals, but none of the primary care hospitals, had adult ID specialists. The proportion of secondary care hospitals that did not have adult ID specialists was 73.2% (P < 0.001). There were no paediatric ID specialists in 45.8%, 87.5% and 97.5%

Table 2
Infrastructure for antimicrobial stewardship programmes (ASPs)

Characteristic	Total (N = 214)	Tertiary care (N = 24)	Secondary care (N = 112)	Primary care (N = 81)	P-value
Existence of antimicrobial management committee [n (%)]	71 (33.2)	20 (83.3)	47 (42.0)	4 (5.1)	<0.001
Medical personnel participating in ASP (FTE/1000 beds) [median (IQR)] [a]					
ID specialists [b]	0 (0–0)	0.32 (0.09–0.72)	0 (0–0)	0 (0–0)	<0.001
Clinical microbiologists	0 (0–0)	0 (0–0.07)	0 (0–0)	0 (0–0)	<0.001
Internal medicine specialists	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0.261
Other specialists	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0.449
Residents or fellows	0 (0–0)	0 (0–0.12)	0 (0–0)	0 (0–0)	<0.001
Clinical pharmacists	0 (0–0)	0 (0–0.17)	0 (0–0)	0 (0–0)	0.001
Nurses	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0.279
Staff in IT department	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0.375
Existence of support for operating ASP [c] [n (%)]	7/113 (6.2)	2/19 (10.5)	3/64 (4.7)	2/30 (6.7)	0.646
Financial support	4/113 (3.5)	0 (0)	3/64 (4.7)	1/30 (3.3)	0.623
Workforce support	3/113 (2.7)	2/19 (10.5)	1/64 (1.6)	0 (0)	0.059
Securing working hours for ASP	5/113 (4.4)	0 (0)	4/64 (6.3)	1/30 (3.3)	0.480
Microbiology laboratory (%)					
Microbiological alert system	175 (81.8)	23 (95.8)	107 (95.5)	45 (55.6)	<0.001
Blood isolates	135 (62.2)	23 (95.8)	88 (78.6)	24 (29.6)	<0.001
Cerebrospinal fluid isolates	94 (43.3)	19 (79.2)	69 (61.6)	6 (7.4)	<0.001
Carbapenem-resistant Enterobacterales	142 (65.4)	19 (79.2)	96 (85.7)	27 (33.3)	<0.001
Vancomycin-resistant enterococci	131 (60.4)	17 (70.8)	88 (78.6)	26 (32.1)	<0.001
Therapeutic drug monitoring					
Vancomycin	88 (40.6)	23 (95.8)	49 (43.8)	16 (19.8)	<0.001
Gentamicin	40 (18.4)	10 (41.7)	21 (18.8)	9 (11.1)	0.003
Amikacin	42 (19.4)	13 (54.2)	20 (17.9)	9 (11.1)	<0.001

FTE, full-time equivalent; IQR, interquartile range; ID, infectious diseases; IT, information technology.
[a] Hospitals that did not operate an ASP were excluded and a total of 209 answers (22 from tertiary care hospitals, 109 from secondary care hospitals and 78 from primary care hospitals) were available.
[b] Includes adult and paediatric ID specialists.
[c] Hospitals that did not operate an ASP were excluded and a total of 113 answers were available.

of tertiary, secondary and primary care hospitals, respectively (P < 0.001).

3.2. Differences in antimicrobial stewardship programme infrastructure

Table 2 shows the infrastructure for the ASPs by hospital type. An antimicrobial management committee existed in 83.3% of tertiary care hospitals compared with only 42.0% and 5.1% of secondary and primary care hospitals, respectively (P < 0.001). ID specialists comprised most medical personnel participating in ASPs in tertiary care hospitals [median 0.32 full-time equivalent (FTE)/1000 beds]. Conversely, in secondary and primary care hospitals there was no predominant medical personnel for ASP and the median FTE was 0 for all types of medical personnel. Only seven hospitals (6.2%; 7/113) provided support to the ASP in terms of finance, workforce or securing working hours, with no significant differences among hospital types.

Active reporting systems for identifying micro-organisms by microbiology laboratories were established in 80.6% of hospitals in this study. The proportion was higher in tertiary and secondary care hospitals compared with primary care hospitals (95.8% vs. 95.5% vs. 55.6%; P < 0.001). Therapeutic drug monitoring (TDM) for vancomycin was established in 95.8% of tertiary care hospitals; the proportion of hospitals performing the test was lower in secondary (43.8%) and primary care hospitals (19.8%) (P < 0.001). Likewise, the proportion of patients undergoing TDM for gentamicin and amikacin was higher in tertiary care hospitals compared with secondary and primary care hospitals.

3.3. Differences in activities for antimicrobial stewardship programmes

Table 3 shows differences in activities for ASPs by hospital type. A significantly higher proportion of tertiary care hospitals than secondary and primary hospitals adopted restrictive measures for designated antimicrobials (100% vs. 45.5% vs. 2.5%, respectively; P < 0.001), formulary restrictions (33.3% vs. 15.2% vs. 27.2%; respectively; P = 0.046) and computerised clinical decision support programs (41.7% vs. 17.9% vs. 1.2%, respectively; P < 0.001). Conversely, a higher proportion of primary care hospitals operated a parenteral-to-oral conversion programme (25.0%, 19.6% and 53.1%, for tertiary, secondary and primary care hospitals, respectively; P < 0.001). The proportion of tertiary care hospitals that performed 'Monitoring and intervention for inappropriate perioperative antimicrobial use' and 'Prospective audit and feedback' was 70.8% and 45.8%, respectively, which was higher than the 47.3% and 17.9% performed in secondary care hospitals and 22.2% and 25.9% performed in primary care hospitals.

All tertiary care hospitals had documented guidelines for antimicrobial use made at any time before the survey, whereas 57.1% of secondary care hospitals and 21.0% of primary care hospitals had these guidelines (P < 0.001). The proportion of hospitals that had educational programmes on appropriate antimicrobial use was lower in primary care hospitals than in the other hospital types (79.2%, 42.0% and 19.8% for tertiary, secondary and primary care hospitals, respectively; P < 0.001).

Tertiary care hospitals, more than secondary and primary care hospitals, tended to monitor and report antimicrobial consumption (79.2% vs. 43.8% vs. 23.5%, respectively; P < 0.001) and appropriateness (100% vs. 71.4% vs. 29.6%; respectively; P < 0.001). Most monitoring and reporting of antimicrobial usage appropriateness was associated with antimicrobial evaluation programmes by the Health Insurance Review & Assessment service (HIRA), which is associated with the support of medical fees in Korea. Monitoring of adverse events of antimicrobials and monitoring and reporting of antimicrobial-resistant pathogens were higher in tertiary care hospitals than in secondary and primary care hospitals.

Table 3
Activities for antimicrobial stewardship programmes

Item	Total (N = 217)	Tertiary care (N = 24)	Secondary care (N = 112)	Primary care (N = 81)	P-value
Action [n (%)]					
Restrictive measures for designated antimicrobials	77 (35.5)	24 (100)	51 (45.5)	2 (2.5)	<0.001
Formulary restriction	47 (21.7)	8 (33.3)	17 (15.2)	22 (27.2)	0.046
Using computerised clinical decision support program	31 (14.3)	10 (41.7)	20 (17.9)	1 (1.2)	<0.001
Parenteral-to-oral conversion strategy	71 (32.7)	6 (25.0)	22 (19.6)	43 (53.1)	<0.001
Monitoring and intervention for inappropriate perioperative antimicrobial use	88 (40.6)	17 (70.8)	53 (47.3)	18 (22.2)	<0.001
Antimicrobial choice	69 (31.8)	16 (66.7)	43 (23.2)	10 (8.6)	<0.001
Duration of antimicrobial use	68 (31.3)	14 (58.3)	41 (36.6)	13 (16.0)	<0.001
Timing of administration	68 (31.3)	12 (50.0)	43 (38.4)	13 (16.0)	<0.001
Administration route	27 (12.4)	6 (25.0)	15 (13.4)	6 (7.4)	0.065
Prospective audit and feedback	52 (24.0)	11 (45.8)	20 (17.9)	21 (25.9)	0.013
Patients with specific infectious diseases	13 (6.0)	2 (8.3)	4 (3.6)	7 (8.6)	0.300
Patients admitted in specific departments	13 (6.0)	4 (16.7)	5 (4.5)	4 (4.9)	0.065
Patients with specific pathogens	27 (12.4)	4 (16.7)	10 (8.9)	13 (16.9)	0.269
Patients who use specific antimicrobials	31 (14.3)	9 (37.5)	10 (8.9)	12 (14.8)	0.001
Documented guidelines for antimicrobial use [n (%)]	105 (48.4)	24 (100)	64 (57.1)	17 (21.0)	<0.001
Empirical antibiotic therapy for infectious diseases	28 (12.9)	9 (37.5)	14 (12.5)	5 (6.2)	<0.001
Surgical prophylactic antimicrobials	78 (35.9)	18 (75.0)	53 (47.3)	7 (8.6)	<0.001
Designated antimicrobial included in restrictive measures	70 (32.3)	20 (83.3)	45 (40.2)	5 (6.2)	<0.001
Educational programmes about appropriate antimicrobial use [n (%)] [a]	82 (37.8)	19 (79.2)	47 (42.0)	16 (19.8)	<0.001
Regular	31 (14.3)	9 (37.5)	19 (17.0)	3 (3.7)	<0.001
Irregular	54 (24.9)	10 (41.7)	31 (27.7)	13 (16.0)	0.024
Target audience					
Physicians, specialists	41/82 (50.0)	9/19 (47.4)	26/47 (55.3)	6/16 (37.5)	0.453
Physicians, trainees	47/82 (57.3)	18/19 (94.7)	28/47 (59.6)	1/16 (6.3)	<0.001
Medical personnel other than physicians	42/82 (51.2)	6/19 (31.6)	25/47 (53.2)	11/16 (68.8)	0.083
Tracking and reporting [n (%)]					
Monitoring and reporting of antimicrobial consumption	87 (40.1)	19 (79.2)	49 (43.8)	19 (23.5)	<0.001
Monitoring and reporting of antimicrobial appropriateness	128 (59.0)	24 (100)	80 (71.4)	24 (29.6)	<0.001
Participation in antimicrobial prescription evaluation for upper respiratory tract infection by HIRA	88/128 (68.8)	19/24 (79.2)	57/80 (71.3)	12/24 (50.0)	0.068
Participation in antimicrobial prescription evaluation for otitis media among children by HIRA	55/128 (43.0)	13/24 (54.2)	39/80 (48.8)	3/24 (12.5)	0.003
Participation in evaluation of antimicrobials for surgical prophylaxis by HIRA	102/128 (79.7)	20/24 (83.3)	66/80 (82.5)	16/24 (66.7)	0.412
Hospital-wide point surveillance for hospitalised patients	24/128 (18.8)	13/24 (54.2)	11/80 (13.8)	0 (0)	<0.001
Monitoring of adverse events due to antimicrobial use	115 (53.0)	22 (91.7)	74 (66.1)	19 (23.5)	<0.001
Monitoring and reporting of antimicrobial-resistant pathogens	132 (60.8)	21 (87.5)	84 (75.0)	27 (33.3)	<0.001

HIRA, Health Insurance Review & Assessment service.
[a] This question requested the respondent to select multiple items.

3.4. Awareness of antimicrobial stewardship programmes

Table 4 shows the differences in awareness levels of ASPs by respondents from the different hospital types. The proportion of respondents who understood the details of ASPs well, such as the 'Seven Core Elements of Hospital Antimicrobial Stewardship Programs' from the CDC, was 78.3% in tertiary care hospitals, which was higher than the 30.9% and 7.9% in secondary and primary care hospitals, respectively ($P < 0.001$). In primary care hospitals, 50.0% said that they had poor understanding of the details of ASPs. Physicians from all three types of hospitals agreed with the statements 'AMR is a matter that directly affects my patients' (6.7 ± 0.6 vs. 6.4 ± 0.9 vs. 6.0 ± 1.1, respectively; $P = 0.005$) and 'Reducing inappropriate antibiotic use in hospitals will reduce AMR' (6.1 ± 0.8 vs. 5.3 ± 1.3 vs. 4.6 ± 1.7, respectively; $P < 0.001$). The statement 'Physicians often prescribe antibiotics that do not conform to guidelines' was agreed with by physicians from tertiary and secondary care hospitals, while those from primary care hospitals did not agree (5.5 ± 0.9 vs. 4.1 ± 1.4 vs. 2.9 ± 1.6; $P < 0.001$). In general, respondents agreed that ASPs positively affect AMR, medical costs, patient safety and prognosis; the mean scores for these factors were higher in tertiary care hospitals than in secondary and primary care hospitals. Similarly, ID specialists assigned higher scores for questions regarding the positive effects of ASPs than non-ID specialists (Supplementary Table S1).

Among the ASP activities, 'Monitoring and intervention for inappropriate perioperative antimicrobial use' (5.3 ± 1.5), 'Parenteral-to-oral conversion strategy' (5.3 ± 1.4) and 'Using computerised clinical decision support program' (5.2 ± 1.4) were the three most necessary activities in Korean hospitals. Similarly, 'Parenteral-to-oral conversion strategy' (4.1 ± 1.5), 'Monitoring and intervention for inappropriate perioperative antimicrobial use' (4.1 ± 1.5) and 'Restrictive measures for designated antimicrobials' (4.0 ± 1.7) were the three most applicable activities in Korean hospitals.

3.5. Demand for establishing or expansion of antimicrobial stewardship programmes in Korean hospitals

Respondents answered that the biggest barrier to establishing or expanding ASPs was 'Lack of personnel' (5.0 ± 1.2), followed by 'Lack of tools' (4.0 ± 1.6) and 'Lack of appropriate reward for operating ASP' (3.6 ± 1.7). Accordingly, 'Workforce for ASP' (4.7 ± 1.4), 'Establishment of healthcare fees for ASP' (4.2 ± 1.5) and 'Development of tools for ASP' (4.1 ± 1.6) were most important required support for ASP improvement. Respondents from hospitals that did not have ID specialists answered that 'Developing in-hospital guidelines for antimicrobial use' (4.6 ± 1.5), 'Education about appropriate antibiotic use for medical personnel' (4.1 ± 1.5) and 'Consultation about appropriate antimicrobial use for patients

Table 4
Awareness of antimicrobial stewardship programmes (ASPs)

Item	Total (N = 209)	Tertiary care (N = 23)	Secondary care (N = 110)	Primary care (N = 76)	P-value
Understanding level of the detail of ASP [n (%)]					
Good	58 (27.8)	18 (78.3)	34 (30.9)	6 (7.9)	<0.001
Fair	92 (44.0)	5 (21.7)	55 (50.0)	32 (42.1)	
Poor	59 (28.2)	0 (0)	21 (19.1)	38 (50.0)	
Awareness of AMR and ASP (mean ± S.D.) [a]					
AMR is a matter that directly affects my patients	6.3 ± 1.0	6.7 ± 0.6	6.4 ± 0.9	6.0 ± 1.1	0.005
Reducing inappropriate antibiotics in hospitals will reduce AMR	5.2 ± 1.5	6.1 ± 0.8	5.3 ± 1.3	4.6 ± 1.7	<0.001
Physicians often prescribe antibiotics that do not conform to guidelines	3.8 ± 1.6	5.5 ± 0.9	4.1 ± 1.4	2.9 ± 1.6	<0.001
ASP can help to reduce AMR	5.4 ± 1.3	6.3 ± 0.8	5.4 ± 1.3	5.1 ± 1.5	<0.001
ASP can improve the prognosis of patients with infectious diseases	5.1 ± 1.3	5.8 ± 0.9	5.2 ± 1.3	4.8 ± 1.3	0.001
ASP can reduce medical costs	5.1 ± 1.5	6.0 ± 1.0	5.2 ± 1.4	4.6 ± 1.7	<0.001
ASP can improve patient safety	5.1 ± 1.4	6.2 ± 0.7	5.2 ± 1.4	4.8 ± 1.5	<0.001
ASP violates individual physicians' autonomy in prescribing rights	4.0 ± 1.5	3.3 ± 1.3	4.0 ± 1.4	4.3 ± 1.6	0.010
ASP causes conflicts among the medical staff	4.3 ± 1.5	4.3 ± 1.5	4.4 ± 1.5	4.1 ± 1.6	0.480
ASP is needed in Korean hospitals	5.2 ± 1.5	6.6 ± 0.7	5.4 ± 1.2	4.5 ± 1.6	<0.001
Necessity of ASP activities in Korean hospitals (mean ± S.D.) [a]					
Monitoring and intervention for inappropriate perioperative antimicrobial use	5.3 ± 1.5	6.3 ± 0.8	5.6 ± 1.3	4.6 ± 1.6	<0.001
Parenteral-to-oral conversion strategy	5.3 ± 1.4	6.2 ± 0.9	5.4 ± 1.2	4.9 ± 1.6	<0.001
Using computerised clinical decision support program	5.2 ± 1.4	6.1 ± 0.8	5.4 ± 1.3	4.5 ± 1.5	<0.001
Prospective audit and feedback	5.2 ± 1.4	6.3 ± 0.8	5.4 ± 1.2	4.6 ± 1.6	<0.001
Restrictive measures for designated antimicrobials	5.1 ± 1.7	6.5 ± 0.7	5.5 ± 1.4	4.1 ± 1.7	<0.001
Developing in-hospital guidelines for antimicrobial use that reflect the status of each hospital	4.9 ± 1.5	5.7 ± 1.2	5.1 ± 1.3	4.3 ± 1.6	<0.001
Formulary restriction	4.6 ± 1.6	5.3 ± 1.6	4.7 ± 1.6	4.3 ± 1.7	0.026
Applicability of ASP activities to Korean hospitals (mean ± S.D.) [a]					
Parenteral-to-oral conversion strategy	4.1 ± 1.5	4.6 ± 1.3	4.1 ± 1.5	4.0 ± 1.6	0.296
Monitoring and intervention for inappropriate perioperative antimicrobial use	4.1 ± 1.5	5.0 ± 1.3	4.2 ± 1.5	3.7 ± 1.5	0.001
Restrictive measures for designated antimicrobials	4.0 ± 1.7	5.4 ± 1.2	4.2 ± 1.7	3.4 ± 1.7	<0.001
Formulary restriction	3.7 ± 1.6	4.5 ± 1.6	3.8 ± 1.6	3.7 ± 1.6	0.104
Using computerised clinical decision support program	3.8 ± 1.6	4.3 ± 1.4	3.9 ± 1.5	3.3 ± 1.6	0.003
Developing in-hospital guidelines for antimicrobial use that reflect the status of each hospital	3.8 ± 1.6	4.7 ± 1.4	3.7 ± 1.7	3.5 ± 1.4	0.007
Prospective audit and feedback	3.7 ± 1.6	4.0 ± 1.7	3.6 ± 1.7	3.6 ± 1.6	0.439

AMR, antimicrobial resistance; S.D., standard deviation.
[a] Each item is measured using a seven-point Likert scale (higher scores mean that the respondent agrees, thinks is necessary or thinks is applicable).

with infectious diseases' (3.5 ± 1.6) were the most sought support from ID specialists (Table 5; Supplementary Table S2).

4. Discussion

Before the current study, four nationwide surveys on ASPs in Korean hospitals had been conducted [12]. However, the studies conducted in 2006, 2012 and 2015 targeted hospitals with ID specialists [18] and the study in 2018 targeted large hospitals with ≥500 beds [12]. This is the first nationwide survey of ASPs in Korea that includes small to medium-sized hospitals. Also, it is the first nationwide survey that identifies the awareness and demands about ASPs by physicians. The results of the present study provide further insights into the status of ASPs in Korean hospitals and identify potential problems with ASPs and demand for improvement of ASPs.

Similar to previous studies, 'Restrictive measures for designated antimicrobials' was the most frequently applied strategy for ASPs in tertiary and secondary care hospitals in Korea [12,18]. In comparison, the proportion of hospitals performing 'Prospective audit and feedback', considered the most important ASP strategy in North America and Europe, was <50% [19,20]. Considering that the 'Prospective audit and feedback' programme is more labour intensive than other interventions, the preference for 'Restrictive measures for designated antimicrobials' might be closely associated with the lack of infrastructure for ASPs in most Korean hospitals [19]. As shown, there were no professions with an average FTE of >1; in fact, less than ten hospitals had a full-time employee responsible for the ASP in Korea (data not shown). Furthermore, hospitals, especially small to medium-sized hospitals, lack ID specialists, considered key members of ASPs along with clinical pharmacists [21]. In a typical ASP team, an ID specialist leads the team and is in charge of implementation and evaluation of the ASP, while clinical pharmacists perform daily tasks with other professions such as clinical microbiologists, infection control nurses and information technology personnel [21,22].

The major ASP activities in primary care hospitals focused on parenteral-to-oral conversion strategy, possibly owing to (i) less labour and expertise required for its implementation than for other ASP activities and (ii) its possible high association with inventory control of medicines in the hospital. Moreover, the strategy might be important for revenue in primary care hospitals. Since many operations that can be performed in primary care hospitals, such as appendectomy, herniorrhaphy, haemorrhoidectomy and Caesarean section, are applied in diagnosis-related groups, switching to oral antibiotics early might raise hospitals' profits [23]. The participation rate of primary care hospitals was relatively high in programmes related to 'Monitoring and reporting of antimicrobial appropriateness', led by and required for medical quality assessment by the HIRA, which is responsible for the support of medical fees in Korea, thus primary care hospitals might have performed them to improve their revenue.

Overall, physicians from all types of hospitals agreed that ASPs are helpful for patient safety and for control of AMR. Interestingly, physicians from tertiary care hospitals agreed strongly with the efficacy of ASPs compared with the other physicians. This discrepancy might have been due to the difference in knowledge and experience in antimicrobial use, as professionals with more

Table 5
Demand for establishing or expansion of antimicrobial stewardship programmes (ASPs) in Korean hospitals

Item	Total (N = 209)	Tertiary care (N = 23)	Secondary care (N = 110)	Primary care (N = 76)
Barriers to establishing or expanding ASPs in Korean hospitals (median ± S.D.) [a]				
Lack of personnel	5.0 ± 1.2	5.7 ± 0.6	4.9 ± 1.3	5.0 ± 1.1
Lack of tools (e.g. guidelines for infectious diseases, CDSS, manuals for ASP)	4.0 ± 1.6	3.3 ± 1.4	3.9 ± 1.7	4.2 ± 1.5
Lack of appropriate reward for operating ASP	3.6 ± 1.7	4.3 ± 1.7	3.5 ± 1.7	3.6 ± 1.7
Lack of education about ASPs	3.4 ± 1.5	2.9 ± 1.4	3.3 ± 1.4	3.7 ± 1.5
Lack of evaluation of ASP operation	2.9 ± 1.3	3.0 ± 1.1	3.0 ± 1.4	2.9 ± 1.2
Lack of punishment for inappropriate antimicrobial use	2.0 ± 1.4	2.0 ± 1.0	2.3 ± 1.5	1.7 ± 1.1
Required support for the improvement of ASPs in Korean hospitals (median ± S.D.) [a]				
Workforce for ASP	4.7 ± 1.4	5.2 ± 1.0	4.6 ± 1.4	4.6 ± 1.4
Establishment of healthcare fee for ASP	4.2 ± 1.5	5.1 ± 1.2	4.3 ± 1.4	3.9 ±1.6
Development of tools for ASPs (e.g. guidelines for infectious diseases, CDSS, manuals for ASP)	4.1 ± 1.6	3.1 ± 1.5	4.0 ± 1.6	4.5 ± 1.6
Establishment of educational programme for ASP	3.3 ± 1.4	2.2 ± 1.1	3.3 ± 1.4	3.6 ± 1.2
Including ASP in qualitative evaluation of hospitals	2.7 ± 1.3	3.2 ± 1.3	2.7 ± 1.4	2.6 ± 1.1
Punishment for inappropriate antimicrobial use	2.0 ± 1.3	2.2 ± 1.2	2.1 ± 1.4	1.9 ± 1.3
ASP activities that require consultation with ID specialists (median ± S.D.) [a,b]				
Developing in-hospital guidelines for antimicrobial use	4.6 ± 1.5	–	4.6 ± 1.6	4.5 ± 1.6
Education about appropriate antimicrobial use for medical personnel	4.1 ± 1.5	–	4.1 ± 1.5	4.1 ± 1.4
Consultation about appropriate antimicrobial use for patients with infectious diseases	3.5 ± 1.6	–	3.4 ± 1.5	3.6 ± 1.8
Establishment of organisational and staffing system for ASP	3.2 ± 1.8	–	3.2 ± 1.5	3.1 ± 1.4
Establishment of programmes regarding 'actions' of ASPs	3.2 ± 1.5	–	3.2 ± 1.7	3.2 ± 1.9
Monitoring and reporting of antimicrobial consumption	2.4 ± 1.4	–	2.4 ± 1.5	2.4 ± 1.3

S.D., standard deviation; CDSS, clinical decision support system; ID, infectious diseases.
[a] Calculated using a priority weighting method (first place, 6 points; second place, 5 points; third place, 4 points; fourth place, 3 points; fifth place, 2 points; and sixth place, 1 point).
[b] We analysed a total of 104 hospitals (58 secondary care hospitals and 46 primary care hospitals) who did not employ ID specialists.

experience with antimicrobial use tended to be more aware of the advantages of ASPs than those with less experience [13,15]. Therefore, to improve the perception of ASPs among physicians in charge of antimicrobials in small to medium-sized hospitals, educational programmes about ASPs may be necessary. Unfortunately, there are currently very limited educational programmes about ASPs in Korea, with most targeted at ID specialists. Given that ASPs are one of the most important strategies for AMR containment, with effects on antimicrobial use, medical costs and patient outcomes, policy-makers should consider the development of educational programmes for ASPs [24].

Respondents thought that the most required support for the improvement of ASPs in Korean hospitals was manpower and the establishment of a healthcare fee for ASPs [12]. Concordant with previous studies, there is a lack of personnel dedicated to ASPs [12]. According to a study in Korea, the personnel required for the review of antibiotics used for >1 week is estimated at 3.01 FTE/1000 beds [25]. A measure that can improve hospitals' attention to ASPs and recruit appropriately qualified individuals to run the programmes might be the establishment of a healthcare fee for ASPs. The Japanese government introduced such a policy in 2018 to help drive the implementation of comprehensive ASPs in hospitals [26]. Considering our experience with improving hospital infection control and prevention systems after the introduction of the reimbursement policy, the establishment of a healthcare fee for ASPs is expected to be effective. Since 2017, hospitals in Korea have been paid US$1.4–2.4/patient/day for activities such as infection surveillance and securing facilities and personnel [14].

The strength of this study is its representativeness. The survey was conducted under authorisation of the KCDC, and all acute care hospitals with ≥150 beds that were registered in the KCDC database were targeted. However, this study has some potential limitations. First, there might be selection bias. The response rate was relatively low (<40%) because the hospitals voluntarily participated in the survey without reward. Given that official letters were sent by the KCDC in order to encourage hospitals to participate in the survey, more hospitals with greater concern for ASPs or governmental policies might have responded to the questionnaire. Second, reporting bias may be present because the results rely on self-reporting. Measurements using objective methods are needed for some issues, including the understanding of ASPs by physicians in charge of antibiotics in the future. Nevertheless, we believe our results reflect ASP status by hospital type because all respondents were the physicians in charge of policies on antibiotics, regardless of specialty.

In conclusion, the level of ASP establishment was more limited in primary care hospitals than in secondary and tertiary care hospitals in Korea. To improve ASPs in Korean hospitals, a supporting workforce and the establishment of a healthcare fee for ASPs appear to be necessary.

Acknowledgments

The authors would like to acknowledge all of the hospitals in this study for their participation in the survey. The authors are also grateful to the Korea Centers for Disease Control and Prevention and the Korean Hospital Association for identifying target participants and sending them an official letter about the survey.

Funding: This work was supported by the Research Program funded by the Korea Centers for Disease Control and Prevention [grant number 2019-P2810-00] and a grant from the Bio & Medical Technology Development Program of the National Research Foundation (NRF) and funded by the Korean government (MSIT) [Funding No. 2019M3E5D1A01066063]. The funders had no role in the study design, data collection and analysis, preparation of the manuscript, or the decision to publish.

Competing interests: None declared.

Ethical approval: The study protocol was approved by the institutional review board of Hanyang University Seoul Hospital [IRB number: 2019-12-025], and the requirement for written informed consent was waived.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jgar.2021.06.001.

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