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Review Article

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Korea's National Action Plan on Antimicrobial Resistance: Focusing on the Appropriate Use of Antibiotics

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ABSTRACT

Antimicrobial resistance (AMR) is recognized as one of the top ten global public health threats. Since the coronavirus disease 2019 pandemic, there has been a notable increase in global concern regarding AMR, leading to a strong call for a government-led response to address this issue. Since 2016, the Korean government has established and implemented a robust social foundation for managing AMR. This foundation encompasses several elements: enhancing the medical environment for infection prevention, providing support for the antimicrobial stewardship program in healthcare organizations, strengthening cooperation among multidisciplinary policy ministries, requiring veterinarians to prescribe antimicrobials in non-human fields, and enhancing food safety management in livestock and aquatic products. However, as the threat of AMR has intensified during the ongoing pandemic, the necessity for implementing a National Action Plan becomes even more critical. Therefore, the Third National Action Plan 2026–2030 is crucial to take into account several critical factors: raising awareness of AMR, strengthening of antimicrobial stewardship, halting the spread of antimicrobial-resistant bacteria, strengthening surveillance of antimicrobial use and AMR rates, strengthening internal and external collaborative efforts to combat AMR, and the final factor to consider is to enhance further antimicrobial development and diagnostic technologies to better manage and prevent AMR.

Keywords: Antimicrobial resistance; Korea; Policy; National action plan; One health

INTRODUCTION

Antimicrobial resistance (AMR) refers to the phenomenon where microorganisms, including bacteria, viruses, fungi, and parasites, develop resistance over time to the drugs used to treat infections [1]. AMR poses a severe threat to global public health by leading to treatment failures, increased mortality among infected patients, high transmissibility among individuals, and significant socioeconomic burdens [2]. In 2019, bacterial AMR directly caused approximately 1.27 million deaths, contributing to an additional 4.95 million deaths related to associated factors [3], representing about 9% of all global deaths (about 13.7 million in 2019) [4]. The death toll from

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AMR is expected to rise, with projections of 1.91 million direct deaths and 8.2 million related deaths by 2050, underscoring the urgency for action [5].

Following the adoption of the Global Action Plan (GAP) on Antimicrobial Resistance by the World Health Organization (WHO) in 2015, global efforts to combat AMR have been mobilized [6, 7]. However, the overuse and inappropriate use of antimicrobials during the coronavirus disease 2019 (COVID-19) pandemic have exacerbated the AMR burden. A survey conducted between October and December 2020 by the WHO Antimicrobial Resistance Surveillance and Quality Assessment Collaborating Centers Network revealed that 63% of the surveyed countries reported an increase in antimicrobial consumption during the pandemic [8]. The WHO noted that although only 8% of patients hospitalized with COVID-19 required antimicrobials for a bacterial infection, about 75% received them "just in case" they might be beneficial [9]. A report by the United States (US) Centers for Disease Control and Prevention (CDC) observed that while deaths from antimicrobial-resistant infection decreased by 18% overall and nearly 30% in hospital between 2012 and 2017 in the US, antimicrobial prescriptions for COVID-19 inpatients surged by nearly 80% in 2020, with a subsequent increase in hospital-acquired infections and deaths from resistant bacteria by more than 15% [10]. The pandemic has complicated national responses to AMR, with most countries prioritizing COVID-19 management. According to the Tripartite AMR Country Self-Assessment Survey for 2020–2021, 94% of participating countries reported that the pandemic impacted their AMR response efforts [11].

As the threat of AMR has intensified during the ongoing pandemic, the necessity for implementing a National Action Plan (NAP) becomes even more critical. In Korea, increases in antimicrobial use and resistance to carbapenem-resistant Enterobacteriaceae (CRE) infection since the onset of the pandemic highlight the need for effective interventions. This study aims to provide a concise review of international trends and the domestic status of AMR and to introduce national AMR control measures centered on Antimicrobial Stewardship Program (ASP) strategies.

INTERNATIONAL TRENDS AROUND AMR

In 2015, the WHO adopted the GAP to tackle AMR and urged all countries to develop a NAP within two years that aligns with the GAP. In 2016, the United Nations (UN) General Assembly convened high-level health officials globally to adopt a political declaration on AMR, committing to combat AMR as a threat to the Sustainable Development Goals (SDGs) [12]. By 2020, the monitoring indicators for the SDGs included the AMR-related indicator "the proportion of bloodstream infections caused by third-generation cephalosporin (3GC)-resistant *Escherichia coli* and methicillin-resistant *Staphylococcus aureus* (MRSA) (3.d.2)." Notably, 3GC-resistant *E. coli* accounted for the most direct (219,000 deaths in 2019) and associated deaths due to AMR, while MRSA represented the deadliest drug-pathogen combination, with 130,000 direct deaths from MRSA infections in 2021 [3, 5, 13].

Despite global efforts, the epidemiological burden of AMR has worsened, as evidenced during the COVID-19 pandemic. There was an increase in inappropriate antimicrobial prescriptions for COVID-19 patients, heightened antimicrobial usage, and rising AMR rates for pathogens [7, 10, 14-16]. This phenomenon has been well confirmed through reports by WHO Pan American Health Organization and Centers for Disease Control and Prevention [14, 15]. In response to the escalating global concern about the severity of AMR problem following the COVID-19 pandemic, there have been many efforts from international community in 2024. Especially, in May 2024, the 77th World Health Assembly endorsed the WHO strategic priorities to address antimicrobial-resistant bacterial infection in the human health sector (2025–2035), including prevention of infections, universal access to quality diagnosis and appropriate treatment, strategic information and innovation and effective governance and financing of the human health sector response to AMR. Also, the WHO Bacterial Priority Pathogens List (BPPL) has been updated again in 2024 based on the first edition to address currrent AMR challenges and provide essential guidance for policymakers, national health authorities and others involved in decisions about R&D and investment related to surveillance and control of antibacterial resistance. In the BPPL 2024, as the critical antimicrobial-resistant bacterial pathogens that pose the greatest threat to public health, carbapenem-resistant Enterobacterales, 3GC-resistant Enterobacterales and carbapenem-resistant *Acinetobacter baumannii* (CRAB) as well as rifampicin-resistance *Mycobacterium tuberculosis* were designated [17]. In addition, world leaders reconvened at the UN General Assembly in 2024 to adopt a second political declaration, reaffirming AMR as one of the most pressing global health threats. Through this

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declaration, UN Member States committed to escalating actions toward clear targets by 2030, emphasizing government accountability and political leadership to ensure universal health coverage. The targets for 2030 included a 10% reduction in global AMR-related deaths from 4.95 million in 2019; each country to have a multisectoral NAP that considers people, animals, plants, and the environment; at least 60% of countries worldwide to finance their NAPs; the Access group antimicrobials of AWaRe to constitute 70% of all antimicrobial use through the ASP; and all countries to report high-quality surveillance data on antimicrobial use and improve access to diagnostics and treatment [18].

AMR-RELATED DISEASE BURDEN AND THE CASE OF KOREA

In 2014, O'Neill estimated that by 2050, AMR could cause 10 million deaths annually worldwide and decrease the gross domestic product by 2% to 3.5%, leading to economic losses of up to USD 100 trillion [19]. This was the inaugural forecasting report on AMR, highlighting its emergence as a critical health issue. The global burden of AMR was first quantified in 2019, revealing 1.27 million deaths directly attributable to AMR and 4.95 million AMR-associated deaths out of an estimated 8.9 million deaths from bacterial infections [3]. A subsequent forecast in 2024 projected 8.22 million annual deaths associated with AMR in 2050, slightly less than earlier predictions but still underscoring the urgency of addressing AMR. Cumulatively from 2025 to 2050, the projections estimate 39.1 million deaths attributable to AMR and 169 million deaths associated with AMR, emphasizing the extensive disease burden [5].

In Korea, the disease burden of AMR has been partially informed by global data. In 2019, AMR was responsible for approximately 7,200 direct deaths and 26,700 related deaths, accounting for about 9% of the total 295,110 annual deaths in the country, making it the third leading cause of death after neoplasms and cardiovascular diseases. The primary pathogens associated with these deaths, in order of prevalence, were *S. aureus* (approximately 7,700 related deaths), *E. coli* (4,500), *Streptococcus pneumoniae* (2,800), *Klebsiella pneumoniae* (approximately 2,100), and *Pseudomonas aeruginosa* (2,000) [20]. Additionally, the WHO Western Pacific Regional Office predicted in its 2023 report that Korea will experience 134,330 AMR-related deaths by 2030, at an economic cost of USD 18.8 billion [21]. In the line with the estimation of global report related to the disease burden due to AMR in Korea, the socioeconomic and clinical burden of six multidrug-resistant organisms (MDRO) relevant to national notifiable infectious diseases in Korea has been also confirmed through domestic research results. The total economic burden of MDRO bacteremia was approximately USD 295 million and unexpected deaths due to MDRO bacteremia were estimated to be 3,280 [22, 23].

Given the established correlation between antimicrobial use and AMR, surveillance of antimicrobial consumption is identified as a critical strategy for addressing AMR. According to data from the Organization for Economic Cooperation and Development (OECD), antimicrobial use in Korea was 25.7 DDD/1,000 inhabitants/day in 2022, which is 36.0% higher than the OECD country average of 18.9 [24]. Antimicrobial use in Korea has been gradually decreasing since 2014 but has increased markedly since the COVID-19 pandemic (**Fig. 1**). The use of antimicrobials increased by 31.8% in 2022 (25.7 DDD/1,000 inhabitants/day) compared to 2021 (19.5) and is projected to continue rising in 2023, spurred by a surge in respiratory infectious disease outbreaks globally, including in Korea [25, 26]. In addressing AMR, it is essential to consider not only the total antimicrobial consumption but also the proportion of Access group antimicrobials within AWaRe. In Korea, the use of Access group antimicrobials constitutes approximately 39% of total antimicrobial consumption, below the 70% target set in the political declaration [27, 28]. Access group antimicrobials, which have a narrower spectrum of activity, are generally recommended for the empiric

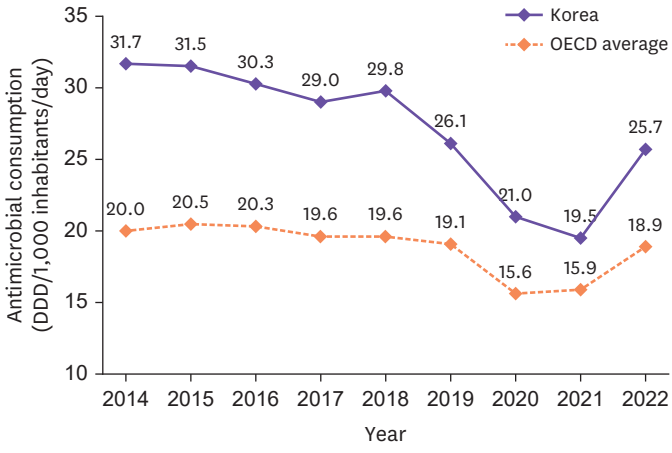

Figure 1. Antimicrobial consumption by year for Korea and OECD member countries (average) (2014–2022).
OECD, The Organization for Economic Cooperation and Development.

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treatment of the most common infections due to their fewer adverse events and lower likelihood of selecting for AMR. In contrast, Reserve group antimicrobials are considered a last resort, intended only for serious infections caused by multidrug-resistant organisms. Therefore, increasing the proportion of Access group antimicrobial use is necessary to mitigate AMR and ensure safer and more effective use of antimicrobials [29].

The findings from the Global Antimicrobial Resistance Surveillance System (GLASS), the WHO system for monitoring antimicrobial-resistant bacteria, have revealed a high level of AMR among pathogens causing bloodstream infections globally [30]. In 2020, resistance to 3GCs in *E. coli* was observed in 41.8% of bloodstream bacterial confirmed infection, while methicillin resistance in *S. aureus* was recorded at 34.7%. Additionally, resistance to third- and fourth-generation cephalosporins in *K. pneumoniae* reached approximately 60%, increasing the reliance on carbapenems. In Korea, rates of 3GC resistance in *E. coli* and methicillin resistance in *S. aureus* were 37.7% and 47.4%, respectively, in 2020. Resistance to third- and fourth-generation cephalosporins in *K. pneumoniae* was 25.4% (cefotaxime) and 19.7% (cefepime) in 2020, respectively. These figures climbed to 31.1% and 25.2% in 2023, marking an increase of over 20% from 2020. Concurrently, resistance to carbapenems escalated from 4.0% in 2020 to 7.2% in 2023 (**Fig. 2**) [31], a significant rise given that carbapenem resistance rates were only in the 1–2% range from 2016 to 2019. This rapid increase in resistance could significantly impact the occurrence and treatment of infections caused by antimicrobial-resistant bacteria. Indeed, the incidence of CRE infections in Korea has shown a marked increase, with *K. pneumoniae* accounting for approximately 70% of these pathogens. The number of CRE cases surged from 11,954 in 2018 to 18,113 in 2020, reaching 38,405 in 2023, and the number of deaths rose from 143 in 2018 to 226 in 2020 and 663 in 2023 (**Fig. 3**) [26, 32].

The Global Action Plan, adopted in 2015, highlighted the improvement of awareness as a crucial goal to address the escalating problem of AMR. It recommended inducing behavior changes on AMR across various sectors, including human health, animal health, and agriculture. The plan emphasized the importance of educating both professionals and the public and advocated for the introduction of school education on the propriate use of antimicrobials and resistance awareness from an early age. Additionally, the WHO has designated November 18

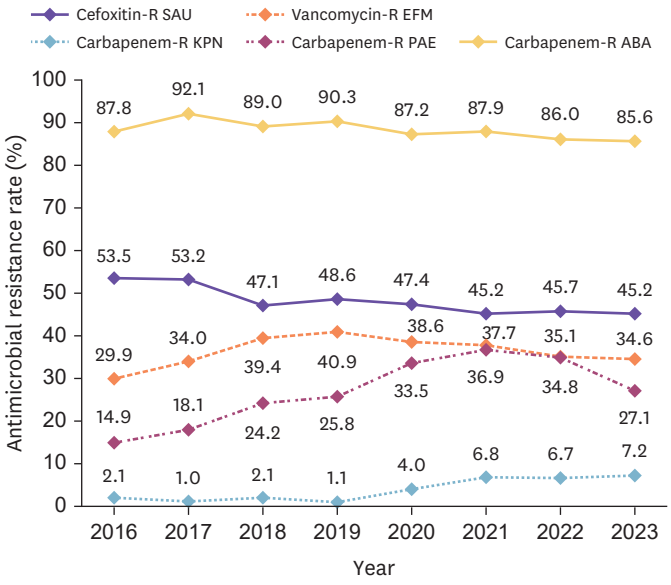

Figure 2. AMR rates by pathogens causing legal communicable diseases by year (2016–2023). These results are from the annual report of national antimicrobial resistance surveillance in Korea 2023, conducted by Korea Disease Control and Prevention Agency.
AMR, Antimicrobial resistance; Cefoxitin-R SAU, Cefoxitin-resistant *Staphylococcus aureus*; Vancomycin-R EFM, Vancomycin-resistant *Enterococcus faecium*; Carbapenem-R KPN, Carbapenem-resistant *Klebsiella pneumoniae*; Carbapenem-R PAE, Carbapenem-resistant *Pseudomonas aeruginosa*; Carbapenem-R ABA, Carbapenem-resistant *Acinetobacter baumannii*.

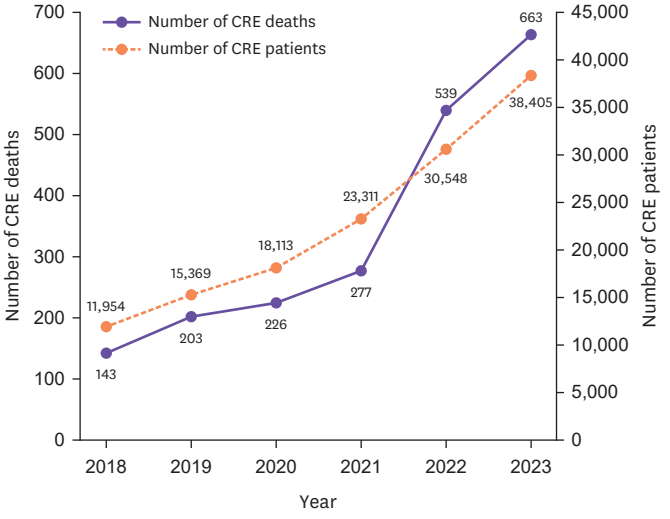

Figure 3. Number of carbapenem-resistant Enterobacteriaceae cases and deaths in Korea by year (2018–2023).
The prevalence of CRE increased significantly since 2018, and the number of deaths attributable to CRE also increased rapidly.
CRE, carbapenem-resistant Enterobacterales.

to 24 as World AMR Awareness Week, an annual global campaign to raise awareness and understanding of AMR. Despite these initiatives, awareness and response capacity for AMR remain insufficient in many countries,

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irrespective of their level of development [33]. In Korea, the results of the "2023 AMR Awareness Survey" conducted by the Korea Disease Control and Prevention Agency indicate a low level of awareness about the severity of AMR, with only 52.9% of respondents recognizing its seriousness. Furthermore, only 28.1% and 20.4% of respondents understood that antimicrobials are used to treat bacterial infections and ineffective in common colds, respectively. These findings underscore the need for enhanced education and public awareness campaigns in Korea to improve understanding of AMR (**Fig. 4**) [34].

FACTORS CONTRIBUTING TO THE OUTBREAK AND SPREAD OF AMR

AMR is a natural phenomenon caused by the selective pressure of antimicrobials when microbes are exposed to them. However, the emergence and acceleration of AMR are exacerbated by the misuse and overuse of antimicrobials. Primary drivers of AMR include the inappropriate and excessive use of antimicrobials in medical treatment, animal production, and agriculture, coupled with inadequate sanitation and poor Infection Prevention and Control (IPC) measures, which serve as key pathways for transmission. The role of environmental factors in the propagation of AMR has gained significant attention recently. Antimicrobials and antimicrobial-resistant bacteria can enter the environment through various pathways, mainly water and soil, spreading to broader environments. This dissemination contaminates agricultural products and poses a threat to human health [35, 36]. Travel also contributes to the geographic spread of resistant bacteria, while the demographic changes due to the aging population and the decrease of investment in the development of new antibiotics increase the disease burden of AMR [5, 36]. Given these and other social, natural, and environmental factors, a comprehensive One Health approach is required to effectively address AMR [35-38].

In Korea, the universal health insurance system provides comprehensive coverage to the entire population, ensuring optimal access to healthcare. This has led to a relatively high rate of antimicrobial use and a correspondingly higher AMR rate among pathogens compared to other countries. Government-led policies on AMR have focused on reducing antimicrobial use in outpatient settings, which account for approximately 90% of total antimicrobial use in the country, and

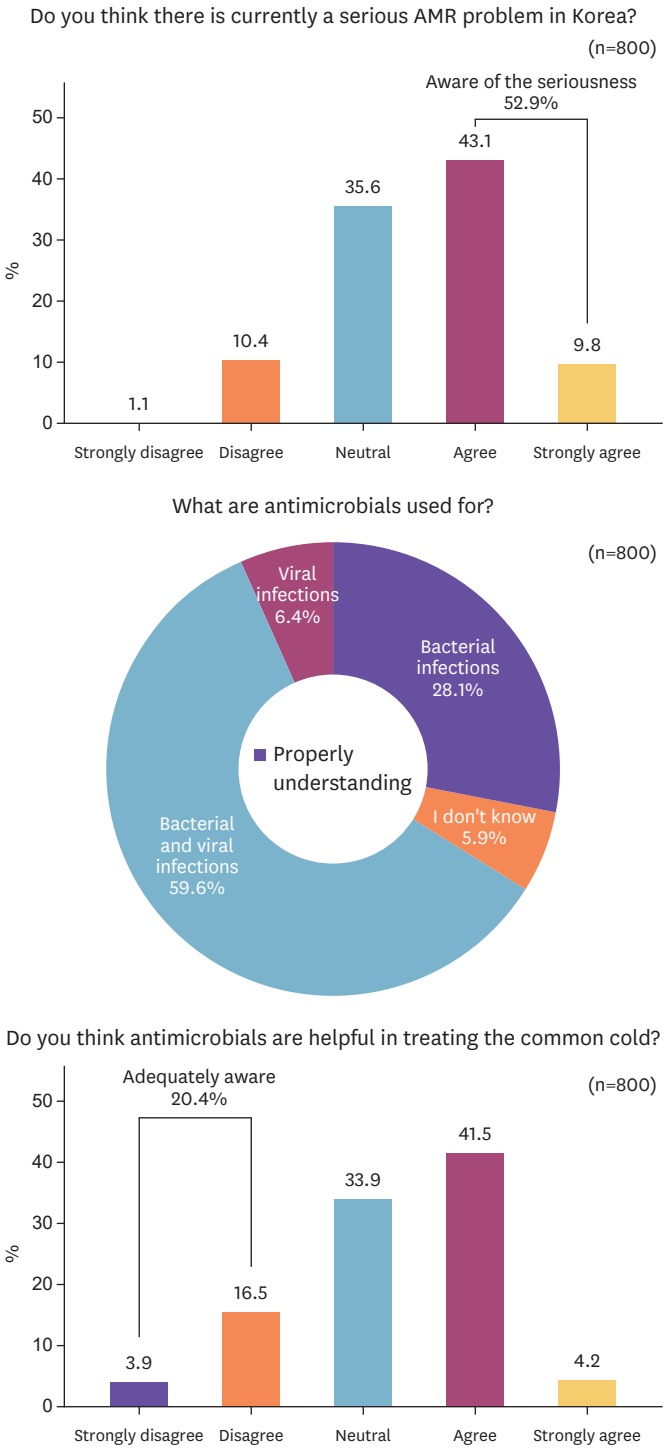

Figure 4. Results of the 2023 AMR awareness survey of the general population in Korea.
AMR, Antimicrobial resistance.

have been particularly effective in reducing usage for upper respiratory tract infections [39]. However, since the pandemic ended, the use of antimicrobials has increased dramatically as bacterial and viral infections

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have become concurrently prevalent. Given the critical role of antibiotics in treating bacterial infections, merely reducing their use is not a viable long-term solution. Therefore, it is now essential to strengthen policies that encourage the "appropriate" use of antimicrobials to address the issue of AMR.

PROGRESS ON AMR CONTROL MEASURES IN KOREA

In 2016, Korea established the "First National AMR Control Plan (2016–2020)" based on the GAP. This plan covered multiple sectors, including human, animal, food, and environmental health, and promoted government-led policies to reduce and appropriately use antimicrobials and prevent the spread of antimicrobial-resistant bacteria. As a result, there was a 17.7% decrease in antimicrobial use in 2020 compared to 2015. Additionally, there was a 14.4% and 18.0% reduction in antimicrobial prescription rates for respiratory tract infections (J00-J47) and acute upper respiratory tract infections (AURIs, J00-J06), respectively, and a 22.0% reduction in methicillin resistance in *S. aureus*. In the animal sector, fluoroquinolone resistance in *E. coli* isolated from chickens decreased by 13.1%. During the implementation of the first plan, key initiatives included the introduction of a financial incentives for IPC to prevent the spread of antimicrobial-resistant bacteria, strengthening facility standards for healthcare organizations, and the establishment of the Korean Global Antimicrobial Resistance Surveillance System (Kor-GLASS) to monitor AMR in Korea according to WHO GLASS guidelines. Additionally, the number of antimicrobials requiring a veterinary prescription increased from 20 to 79. On-farm safety management standards (Hazard Analysis and Critical Control Point, HACCP) and antimicrobial-free certification standards were enhanced, and a multi-ministerial surveillance system for agriculture, livestock, and fisheries was established [40].

The "Second National Action Plan to Combat Antimicrobial Resistance (2021–2025)" was subsequently developed to promote sustainable health through controlling AMR in humans, animals, and the environment. The plan set two main goals: (1) to reduce antimicrobial-resistant bacteria by appropriately using antimicrobials where necessary, and (2) to curb the spread of resistant bacteria through strengthening the surveillance systems and IPC support. The implementation of these objectives is currently underway across five primary domains: appropriate use of antimicrobials, prevention of the dissemination of antimicrobial-resistant bacteria, enhancement of surveillance systems, expansion of research and development, and fortification of AMR management cooperation. The core strategy of the second plan was to establish a foundation for ASP in healthcare organizations. Through communication and cooperation with the academic community, the government launched the ASP pilot project using health insurance reimbursement in November 2024. In the wake of the COVID-19 pandemic, with rising outbreaks of bacterial respiratory infections, increasing antimicrobial use, and emerging resistance to broad-spectrum antimicrobials, promoting "responsible and prudent use" of antimicrobials has become a timely policy intervention.

LAYING THE FOUNDATION FOR AMR CONTROL: STRENGTHENING SURVEILLANCE SYSTEM AND ASP

1. Strenthening AMR surveillance system

The surveillance of antimicrobial use and resistance rates is fundamental in assessing the incidence and dissemination of AMR, as well as in monitoring the impact of national policies. In Korea, antimicrobial surveillance includes the Korea National Antimicrobial Use Analysis System (KONAS), Kor-GLASS, and the Korea Antimicrobial Resistance Monitoring System (KARMS).

KONAS is an antimicrobial use surveillance system that encourages healthcare organizations to judiciously utilize antimicrobials by monitoring, comparing, and analyzing antimicrobial use patterns and returning the results. Participation in KONAS is mandatory for healthcare organizations involved in the 2024 ASP pilot project and is open to general hospitals and higher. Information about antimicrobial use in Korean healthcare organizations is publicly available through the KONAS annual report. According to the 2024 KONAS annual report, in 2022, the rate of antimicrobial use in tertiary and general hospitals nationwide was 906.5 DOTs/1,000 patient-days, the highest since 2018, showing increases of 4.41% in tertiary hospitals (994.3 DOTs/1,000 patient-days), 11.7% in general hospitals (854.7 DOTs/1,000 patient-days), and 28.0% in primary healthcare providers (678.1 DOTs/1,000 patient-days) compared to 2021 [41]. The most frequently prescribed antimicrobials in these hospitals were third- and fourth-generation cephalosporins, followed by first- and second-generation cephalosporins and quinolones.

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Kor-GLASS, the national antimicrobial resistance surveillance system, is a standardized domestic surveillance system for multidrug-resistant organisms. It is based on the WHO GLASS manual and was first operationalized in 2016 when Korea joined the WHO GLASS initiative. Since then, the scope of testing has continuously expanded. In 2023, 15 pathogens were collected from six types of samples across 10 regions from general hospitals nationwide and analyzed for AMR. Notably, resistance trends for carbapenem-resistant *K. pneumoniae* (CRKP) and fluoroquinolone-resistant *E. coli* continued to rise, while carbapenem-resistant *P. aeruginosa*, CRAB, MRSA, and vancomycin-resistant enterococci showed decreasing trends [31]. KARMS is another surveillance system that tracks antimicrobial resistance trends in small and medium-sized hospitals, long-term care facilities, and doctors' offices across the country. It relies on susceptibility results from nine pathogens tested at five clinical testing centers in Korea. In 2023, a total of 4,936 medical institutions participated, with resistance information collected and analyzed for 394,894 specimens. According to the "National Antimicrobial Resistance Surveillance Annual Report" of 2023, resistance rates were generally higher in long-term care facilities than in general hospitals, small and medium-sized hospitals, and clinics for all blood isolates analyzed [31]. CRKP, in particular, demands attention as its resistance rate reached 32.9% in 2023, marking a significant increase of 10.7 percentage points from 22.2% in 2022.

2. Introduction of the ASP pilot project

Globally, inappropriate prescriptions account for approximately 30–50% of all antimicrobials prescribed by healthcare organizations. In Korean general hospitals and higher-level facilities, the rate of inappropriate prescriptions is similar at about 28%, underscoring the need for ASPs [42-44].

ASPs are integrated and systematic interventions that assist healthcare organizations in leveraging evidence-based methodologies to ensure that patients receive the appropriate antimicrobial at the optimal dose for the designated duration [45]. ASPs have been shown to improve patient outcomes, reduce *Clostridioides difficile* infections and adverse drug reactions, and further minimize healthcare costs and AMR [46, 47]. To effectively implement ASP policies and integrate them into healthcare settings, governments need to take the lead in strengthening and supporting the ASP infrastructure. In 2014, the CDC outlined seven core elements for implementing ASPs in healthcare organizations: leadership commitment, accountability, pharmacist expertise, action, tracking, reporting, and education [48, 49]. Considering the situation in Korea where there is a shortage of infectious disease specialists and pharmacists, the government combined the "accountability" and "pharmacist expertise" elements into an "operating system", which involves organizing a multidisciplinary ASP team, and distributed the "Guidelines on implementing ASPs in Korea" on the basis of the adjusted six core elements [50-52]. Furthermore, the government has developed and disseminated guidelines for the use of antimicrobials in treating common infectious syndromes such as respiratory tract infections, urinary tract infections, and skin and soft tissue infections. These guidelines aim to assist healthcare organizations in appropriately prescribing antimicrobials, thereby enhancing patient care. Recently, the government has been developing clinical pathways and antimicrobial-specific usage guides, supplementing the existing core question format, in order to facilitate the application of antimicrobial use guidelines in healthcare settings along with the launch of the ASP pilot project. In 2024, a clinical pathway for managing frequent infectious disease syndromes in long-term care facilities, where high rates of AMR have been a concern, and an antimicrobial-specific usage guide were developed [53]. Besides, in an effort to establish ASPs within healthcare organizations, the government has initiated a series of policies that include establishing a training system for ASP personnel and disseminating AMR surveillance information across Korea.

Doctors and pharmacists play a pivotal role in the implementation of ASPs within healthcare organizations, necessitating their active involvement and thorough knowledge of ASP principles. Consequently, the government is collaborating with professional societies to enhance the understanding of ASPs among doctors and pharmacists and to develop specialized training programs tailored to specific job roles. These programs are designed to facilitate the implementation of ASPs in clinical practice.

However, a 2020 survey of doctors at Korean healthcare organizations identified "insufficient staffing" as the most significant challenge in ASP implementation, highlighting a need for "dedicated staff support" and "new reimbursement items" to effectively implement ASPs at healthcare sites [54]. In response, the government, after

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Table 1. Assessment items for the ASP pilot project

Classification	Assessment item
A. Basic items	A.1.1 Organization and operation of a dedicated ASP team
	A.1.2 Organization and operation of ASP committees and reporting of operational results to management
	A.2.1 Formulation and enforcement of antimicrobial use guidelines
	A.3 ASP activities
	Intervention
	A.3.1 Audit and feedback on antimicrobial use
	A.3.2 Operation of a restricted antimicrobial approval program
	Follow-up
	A.3.3 KONAS enrollment status
	A.3.4 Routine follow-up for CDI
	Education
	A.3.5 Education on antimicrobial prescription guidelines
	A.3.6 Education on ASP
	A.4.1 Reporting on ASP activity results (indicator-based)
B. Additional items	B.1.1 Professional staffing
	B.1.2 Reallocation of budgets
	B.2.1 Active implementation of interventions
	B.2.2 Computerization of the management program

ASP, antimicrobial stewardship program; KONAS, Korea National Antimicrobial Use Analysis System; CDI, *Clostridium difficile* infection.

consulting with experts and stakeholders, introduced the ASP Pilot Project, utilizing health insurance reimbursement for general hospitals with more than 300 beds that meet required staffing standards. Launched in November 2024, the ASP pilot project includes 78 tertiary and general hospitals across Korea and is set to run for three years and two months until December 2027. The project focuses on building infrastructure, including the establishment and operation of ASP teams and committees to manage the appropriate use of antimicrobials. It also encompasses ASP activities such as interventions, follow-ups, and education on antimicrobial prescription by healthcare providers, which require the participation and support of hospital management (**Table 1**). The success of the ASP pilot program requires the participation and active support of hospital management. This is because interventions for appropriate antibiotic use require adequate staffing and funding, and ASP results must be reported and utilized within the healthcare institution for AMR management. Also, all of doctors and pharmacists, excluding infectious disease specialists, who are part of dedicated teams for ASP in healthcare organizations participating in the ASP pilot project launched in November 2024, are required to complete ASP training. Based on their knowledge and experience, they are also tasked with providing annual training to doctors, healthcare workers, and management on the correct prescription and use of antimicrobials.

Another critical factor for the success of ASP is multidisciplinary collaboration within the healthcare organizations. Implementation of ASP requires communication and collaboration among all disciplines, including infectious disease specialists, pharmacists, physicians from various specialties who prescribe antimicrobials, clinical microbiologists, nurses, and information officers.

This pilot project is expected to lay the foundation for implementing ASPs in Korean healthcare organizations. The outcomes of this pilot will inform the subsequent expansion of ASPs to the hospital level, including long-term care facilities.

DISCUSSIONS ABOUT FUTURE POLICIES

The year 2025 marks the final year of implementation for the "Second National AMR Control Plan". In the meantime, the government has enacted several policies aimed at protecting the Korean populace from AMR. These measures include enhancing the healthcare environment, advancing ASPs through the ASP pilot project, strengthening interdisciplinary communication and collaboration among relevant policy ministries, directing veterinarians to prescribe antimicrobials in non-human domains, and improving food safety oversight for livestock and aquatic products, which includes antimicrobial-free certification and establishing standards for permissible antimicrobial residues. Despite these concerted efforts, Korea's AMR-related indicators have not shown significant improvement. This stagnation can

be attributed to a range of factors, including external influences such as the COVID-19 pandemic, a national health insurance system that ensures broad access to healthcare, and a public attitude that is relatively tolerant toward antimicrobial use. Without robust interventions, antimicrobial resistance and the associated disease burden are expected to increase by factors such as an aging population, shorter epidemic cycles, increased outbreaks of infectious diseases, climate change, and augmented travel. Therefore, impactful and rigorous policies to address the underlying causes of AMR occurrence and their dissemination are required across all domains where antimicrobials are used, including human, animal, plant, and food sectors. Looking ahead, the impending "Third National Action Plan on AMR," covering the years 2026 to 2030, needs to include the formulation of more effective policies than those currently in place through examination of the predominant causes and ramifications of AMR.

Therefore, the direction of future government policy should take into account several critical factors based on the action goals outlined in the UN Political Declaration. The first factor is raising awareness of AMR. Public awareness is crucial in tackling AMR, and understanding both AMR itself and the proper use of antimicrobials needs to be instilled across society. This requires tailored training for all stakeholders in each sector where antimicrobials are used and ongoing dissemination of educational materials to the general population. Particularly, schooling from an early age should be performed to shape attitudes toward appropriate antimicrobial use. The second factor is the strengthening of antimicrobial stewardship. Beginning with the ASP pilot project launched for healthcare organizations in 2024, ASPs should be established and expanded to include all healthcare organizations, such as small and medium-sized hospitals, long-term care facilities, and clinics. Additionally, the need for ASPs in animals and plants is emphasized by the fact that antimicrobial use in agriculture accounts for approximately 70% of global antimicrobial consumption. The government must identify and actively promote the most effective tools and strategies for antimicrobial stewardship across all sectors, including human, animal, plant, and food sectors. The third factor is strengthening immunization and IPC in healthcare organizations to prevent infections and halt the spread of antimicrobial-resistant bacteria. In Korea, where AMR rates are relatively high, policies that accelerate the introduction of new antimicrobials are also crucial. These policies aim to enhance treatment efficacy for patients infected with multidrug-resistant organisms and to curb the spread of these organisms within healthcare settings. Additionally, the adoption and implementation of non-human infection prevention strategies in animal agriculture are necessary. Effective infection prevention can lead to reduce antimicrobial use and improve production in agriculture. The fourth factor is the increased surveillance of antimicrobial use and AMR rates. Given the potential for AMR to emerge and spread among all living organisms, including humans, animals, plants, and the environment, there is compelling evidence that surveillance measures need to be reinforced across all sectors. This is to monitor new resistances and shifts in existing ones. An integrated surveillance approach, grounded in a "one-health" framework, is imperative to understand the complex interactions among humans, animals, plants, and the environment. Fifth, in light of the growing international focus on AMR and the crucial interconnections between humans, animals, and the environment, it is essential to strengthen both our internal and external collaborative efforts to combat AMR and proactively address global concerns. The final factor to consider is research and development. The formulation of AMR management policies and strategies must be based on solid research and scientific evidence. Given the propensity for antimicrobials to develop resistance, it is crucial to develop non-antimicrobial treatments as alternatives, alongside further antimicrobial development. Additionally, there is a need to enhance diagnostic and detection technologies to better manage and prevent AMR.

AMR is not only a naturally occurring phenomenon but is also accelerated by antimicrobial use, making it challenging to control without strong measures. To ensure the success of the Third National AMR Control Plan and effectively address the AMR issue, it is crucial that all government departments recognize AMR as a serious public health threat. These departments must collaborate to establish it as a policy priority across all sectors, including human, animal, plant, and environmental health. Additionally, they must engage with relevant stakeholders, such as the healthcare community and experts, to foster a comprehensive approach to combating AMR.

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REFERENCES

1. World Health Organization (WHO). Antimicrobial resistance. Available at: https://www.who.int/news-room/questions-and-answers/item/antimicrobial-resistance. Accessed 19 February 2025.
2. World Health Organization (WHO). Ten threats to global health in 2019. Available at: https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019. Accessed 19 February 2025.
3. Antimicrobial Resistance Collaborators. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. Lancet 2022;399:629-55. PUBMED | CROSSREF
4. GBD 2019 Antimicrobial Resistance Collaborators. Global mortality associated with 33 bacterial pathogens in 2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet 2022;400:2221-48. PUBMED | CROSSREF
5. GBD 2021 Antimicrobial Resistance Collaborators. Global burden of bacterial antimicrobial resistance 1990-2021: a systematic analysis with forecasts to 2050. Lancet 2024;404:1199-226. PUBMED | CROSSREF
6. World Health Organization (WHO). Global action plan on antimicrobial resistance. 2015. Available at: https://iris.who.int/bitstream/handle/10665/193736/978924150+763_eng.pdf?sequence=1. Accessed 28 February 2025.
7. World Health Organization (WHO). Sixty-eighth world health assembly: resolutions and decisions. Available at: https://apps.who.int/gb/ebwha/pdf_files/wha68-rec1/a68-r1-en.pdf. Accessed 1 March 2025.
8. Tomczyk S, Taylor A, Brown A, de Kraker MEA, El-Saed A, Alshamrani M, Hendriksen RS, Jacob M, Löfmark S, Perovic O, Shetty N, Sievert D, Smith R, Stelling J, Thakur S, Vietor AC, Eckmanns T; WHO AMR Surveillance and Quality Assessment Collaborating Centres Network. Impact of the COVID-19 pandemic on the surveillance, prevention and control of antimicrobial resistance: a global survey. J Antimicrob Chemother 2021;76:3045-58. PUBMED | CROSSREF
9. World Health Organization. WHO reports widespread overuse of antibiotics in patients hospitalized with COVID-19. Available at: https://www.who.int/news/item/26-04-2024-who-reports-widespread-overuse-of-antibiotics-in-patients--hospitalized-with-covid-19. Accessed 1 March 2025.
10. Centers for Disease Control and Prevention (CDC). COVID-19: U.S. impact on antimicrobial resistance. 2022 special report. Available at: https://stacks.cdc.gov/view/cdc/119025/cdc_119025_DS1.pdf. Accessed 28 February 2025.
11. Food and Agriculture Organization of the United Nations, World Organization for Animal Health, World Health Organization. Tripartite AMR country self-assessment survey-TrACSS (6.0) 2022. Available at: https://www.who.int/publications/m/item/tripartite-amr-country-self-assessment-survey---tracss-(6.0)-2022. Accessed 28 February 2025.
12. Aslam B, Asghar R, Muzammil S, Shafique M, Siddique AB, Khurshid M, Ijaz M, Rasool MH, Chaudhry TH, Aamir A, Baloch Z. AMR and sustainable development goals: at a crossroads. Global Health 2024;20:73. PUBMED | CROSSREF
13. World Health Organization (WHO). Sustainable development goals (SDGs) AMR indicator. Available at: https://www.who.int/data/gho/data/themes/topics/global-antimicrobial-resistance-surveillance-system-glass/sustainable-development-goals-amr-indicator. Accessed 1 March 2025.
14. Pan American Health Organization (PAHO). Antimicrobial resistance, fueled by the COVID-19 pandemic. Policy Brief, November 2021. Available at: https://iris.paho.org/handle/10665.2/55864. Accessed 20 February 2025.
15. Centers for Disease Control and Prevention (CDC). Antimicrobial resistance threats in the United States, 2021-2022. Available at: https://www.cdc.gov/antimicrobial-resistance/data-research/threats/update-2022.html. Accessed 20 February 2025.
16. Abdelaziz Abdelmoneim S, Mohamed Ghazy R, Anwar Sultan E, Hassaan MA, Anwar Mahgoub M. Antimicrobial resistance burden pre and post-COVID-19 pandemic with mapping the multidrug resistance in Egypt: a comparative cross-sectional study. Sci Rep 2024;14:7176. PUBMED | CROSSREF
17. World Health Organization (WHO). WHO bacterial priority pathogens list, 2024. Available at: https://www.who.int/publications/i/item/9789240093461. Accessed 27 March 2025.
18. United Nations (UN). Political declaration of the high-level meeting on antimicrobial resistance. 2024. Available at: https://www.un.org/pga/wp-content/uploads/sites/108/2024/09/FINAL-Text-AMR-to-PGA.pdf. Accessed 20 February 2025.
19. O'Neill J. Antimicrobial resistance: tackling a crisis for the health and wealth of nations. London: Review on Antimicrobial Resistance, 2014. Available at: https://amr-review.org/sites/default/files/AMR%20Review%20Paper%20-%20Tackling%20a%20crisis%20for%20the%20health%20and%20wealth%20of%20nations_1.pdf. Accessed 20 February 2025.
20. Institute for Health Metrics and Evaluation (IMHE). The burden of antimicrobial resistance (AMR) in Republic of Korea. Available at: https://www.healthdata.org/sites/default/files/2023-09/S_Korea.pdf. Accessed 1 March 2025.
21. World Health Organization (WHO, Western Pacific Region). Health and economic impacts of antimicrobial resistance in the Western Pacific Region, 2020-2030. Available at: https://www.who.int/publications/i/item/9789290620112. Accessed 1 March 2025.
22. Song KH, Kim CJ, Choi NK, Ahn J, Choe PG, Park WB, Kim NJ, Choi HJ, Bae JY, Kim ES, Lee H, Park JS, Jung Y, Lee SS, Park KH, Jung SI, Kim YS, Bang JH, Lee S, Kang YM, Kwak YG, Kim

HB; Korea INfectious Diseases (KIND) Study Group. Clinical and economic burden of bacteremia due to multidrug-resistant organisms in Korea: a prospective case control study. J Glob Antimicrob Resist 2022;31:379-85. PUBMED | CROSSREF

23. Kim CJ, Song KH, Choi NK, Ahn J, Bae JY, Choi HJ, Jung Y, Lee SS, Bang JH, Kim ES, Moon SM, Song JE, Kwak YG, Chun SH, Kim YS, Park KH, Kang YM, Choe PG, Lee S, Kim HB; Korea INfectious Diseases (KIND) Study Group. Socioeconomic burden of pneumonia due to multidrug-resistant *Acinetobacter baumannii* and Pseudomonas aeruginosa in Korea. Sci Rep 2022;12:13934. PUBMED | CROSSREF
24. Organisation for Economic Co-operation and Development (OECD). OECD data explorer. Available at: https://data-explorer.oecd.org. Accessed 20 February 2025.
25. National Institute of Health. Antimicrobial usage (human). Available at: https://nih.go.kr/nohas/statistics/selectAUStatisticsMainTab.do. Accessed 1 March 2025.
26. Korea Disease Control and Prevention Agency (KDCA). Annual report on the notified infectious diseases in Korea, 2023. Available at: https://dportal.kdca.go.kr/pot/bbs/BD_selectBbs.do?q_bbsSn=1010&q_bbsDocNo=2024062817401636l&q-clsfNo=1. Accessed 22 February 2025.
27. World Health Organization (WHO). Antibiotic use: pattern of antibiotic use at national level (relative use by AWaRe classification). Available at: https://www.who.int/data/gho/indicator-metadata-registry/imr-details/5765. Accessed 22 February 2025.
28. World Health Organization (WHO). The WHO AWaRe (Access, Watch, Reserve) antibiotic book. 2002. Available at: https://www.who.int/publications/i/item/9789240062382. Accessed 22 February 2025.
29. Zanichelli V, Sharland M, Cappello B, Moja L, Getahun H, Pessoa-Silva C, Sati H, van Weezenbeek C, Balkhy H, Simão M, Gandra S, Huttner B. The WHO AWaRe (access, watch, reserve) antibiotic book and prevention of antimicrobial resistance. Bull World Health Organ 2023;101:290-6. CROSSREF
30. World Health Organization (WHO). Global antimicrobial resistance and use surveillance system (GLASS) report 2022. Available at: https://iris.who.int/bitstream/handle/10665/364996/9789240062702-eng.pdf?sequence=1. Accessed 22 February 2025.
31. Korea Disease Control and Prevention Agency (KDCA). National antimicrobial resistance surveillance in Korea, 2023 annual report. Available at: https://www.kdca.go.kr/board/board.es?mid=a20310030000&bid=0132. Accessed 22 February 2025.
32. Lim J, Sim J, Lee H, Hyun J, Lee S, Pakr S. Characteristics of carbapenem-resistant *Enterobacteriaceae* (CRE) in the Republic of Korea, 2022. Public Health Wkly Rep 2024;17:115-27.
33. Satria FB, Tsai FJ. Awareness and capacities of 103 countries to address antimicrobial resistance from 2017 to 2020. Sci Rep 2024;14:30184. PUBMED | CROSSREF
34. Korea Disease Control and Prevention Agency (KDCA). Press releases: 'Hang-pil-je-sa' antibiotics should be used properly only when necessary. 2024. https://www.kdca.go.kr/board/board.es?mid=a20501010000&bid=0015&list_no=726492&cg_code=&act=view&nPage=1&newsField=. Accessed 4 March 2025.
35. Ahmed SK, Hussein S, Qurbani K, Ibrahim RH, Fareeq A, Mahmood KA, Mohamed MG. Antimicrobial resistance: impacts, challenges, and future prospects. J Med Surg Public Health 2024;100081. CROSSREF
36. Holmes AH, Moore LS, Sundsfjord A, Steinbakk M, Regmi S, Karkey A, Guerin PJ, Piddock LJ. Understanding the mechanisms and drivers of antimicrobial resistance. Lancet 2016;387:176-87. PUBMED | CROSSREF
37. Prestinaci F, Pezzotti P, Pantosti A. Antimicrobial resistance: a global multifaceted phenomenon. Pathog Glob Health 2015;109:309-18. PUBMED | CROSSREF
38. Endale H, Mathewos M, Abdeta D. Potential causes of spread of antimicrobial resistance and preventive measures in one health perspective-a review. Infect Drug Resist 2023;16:7515-45. PUBMED | CROSSREF
39. Kim BN, Kim HB, Oh MD. Antibiotic control policies in South Korea, 2000-2013. Infect Chemother 2016;48:151-9. PUBMED | CROSSREF
40. Lee HW, Ryu S, Jeong GY, Kang KM, Yoo H. Introduction to the antimicrobial stewardship program: its current status and policy direction in the Republic of Korea. Public Health Wkly Rep 2022;15:2971-3003.
41. Korea Disease Control and Prevention Agency (KDCA). Antimicrobial use in Korean hospitals: results of 110 participating hospitals in 2023. Available at: https://www.kdca.go.kr/board/board.es?mid=a20310030000&bid=0132. Accessed 2 March 2025.
42. Centers for Disease Control and Prevention (CDC). Strategies to assess antibiotics use to drive improvements in hospitals. Available at: https://www.cdc.gov/antibiotic-use/healthcare/pdfs/strategies-to-assess-antibiotic-use-in-hospitals-508.pdf. Accessed 2 March 2025.
43. Goossens H, Vlieghe E, Versporten A, Pauwels I. The global point prevalence survey of antimicrobial consumption and resistance: impact and value. 2023 edition. Available at: https://www.global-pps.com/wp-content/uploads/2023/03/2023-GLOBAL-PPS-Selection-of-Publications-FINAL-INTERACTIVE-LINKS-V2-1.pdf. Accessed 2 March 2025.
44. Australian Government. Department of Health and Aged Care. Antimicrobial prescribing practice in Australian hospitals: results of the 2021 hospital national antimicrobial prescribing survey. Available at: https://www.amr.gov.au/sites/default/files/2024-01/antimicrobial-prescribing-practice-in-australian-hospitals-results-of-the-2021-hospital-national-antimicrobial-prescribing-survey.pdf. Accessed 2 March 2025.
45. Dyar OJ, Huttner B, Schouten J, Pulcini C; ESGAP (ESCMID Study Group for Antimicrobial stewardshiP). What is antimicrobial stewardship? Clin Microbiol Infect 2017;23:793-8. PUBMED | CROSSREF
46. Baur D, Gladstone BP, Burkert F, Carrara E, Foschi F, Döbele S, Tacconelli E. Effect of antibiotic stewardship on the incidence of infection and colonisation with antibiotic-resistant bacteria and *Clostridium difficile* infection: a systematic review and meta-analysis. Lancet Infect Dis 2017;17:990-1001. PUBMED | CROSSREF
47. Kim B, Kim J, Kim SW, Pai H. A survey of antimicrobial stewardship programs in Korea, 2015. J Korean Med Sci 2016;31:1553-9. PUBMED | CROSSREF
48. Centers for Disease Control and Prevention (CDC). The core elements of hospital antibiotic stewardship programs: 2019. Available at: https://www.cdc.gov/antibiotic-use/healthcare/pdfs/hospital-core-elements-H.pdf. Accessed 2 March 2025.
49. National Institute for Health and Care Excellence (NICE). Antimicrobial stewardship: systems and processes for effective antimicrobial medicine use. Available at: https://www.nice.org.uk/guidance/ng15/resources/antimicrobial-stewardship-systems-and-processes-for-effective-antimicrobial-medicine-use-pdf-1837273110469. Accessed 2 March 2025.

50. Korea Disease Control and Prevention Agency (KDCA). Antimicrobial stewardship program (ASP) guideline. 2023. Available at: https://www.kdca.go.kr/contents.es?mid=a20310010200. Accessed 4 March 2025.
51. 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
52. 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. PUBMED | CROSSREF
53. Korea Disease Control and Prevention Agency (KDCA). Development of clinical guidelines for frequent infections in long-term care hospitals. 2024. Available at: https://www.prism.go.kr/homepage/entire/researchDetail.do?researchId=1790387-202400054&menuNo=I0000003&gubun=organtheme. Accessed 2 March 2025.
54. Lee MJ, Moon SM, Kim B, Park SY, Park JY, Koo H, Lee H, Song KH, Lee H, Park JS, Lee MS, Choi SM, Kim CJ, Chang HH, Kim TH, Park SH, Kim ES, Kim HB; Korea Study Group for Antimicrobial Stewardship (KOSGAP). 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. J Glob Antimicrob Resist 2021;26:180-7. PUBMED | CROSSREF