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Are we investing wisely? A systematic analysis of nationally funded antimicrobial resistance projects in Republic of Korea, 2003–2013

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ABSTRACT

From 2003 to 2013, South Korea has conducted the National Antimicrobial Resistance Safety Control Program (NARSCP). The purpose of the current study was to systematically review national antimicrobial resistance (AMR) research trends and to provide guidance on future allocation of research funding to enable a comprehensive approach in AMR control. This study collected project reports related to AMR published by the Ministry of Food and Drug Safety, the Ministry of Health and Welfare and the Korea Centers for Disease Control and Prevention between 2003 and 2013. These reports were analysed by topics based on the AMR action plan of the World Health Organization (WHO), period of study, categories along the research pipeline and types of receiving institution. A total of 198 project reports were included, with total funding of US$18.3 million. Mean funding per award was US$92,750, with a median of US$71,714. Among the WHO-suggested criteria, the basic microbial research and surveillance sector accounts for 143 (72.2%) of all awards. Yearly project funding increased from US$961,476 in 2003 to US$1,553,294 in 2013. Operational research was 61.5% and product development was 0.7% of the basic microbial research and surveillance sector. By institution, academia received 145 awards (73.2%). During progress of the NARSCP, total research funding increased significantly, but most awards were focused on understanding the overall picture of the nationwide AMR status. More balanced funding is needed, and encouraging active participation of private and international sectors is also required in reducing AMR.

1. Introduction

Antimicrobial agents play a crucial role in the treatment of infectious diseases. However, excessive and inappropriate use of antimicrobial agents has caused global increases in antimicrobial resistance (AMR) [1–3]. The emergence of resistant bacteria has resulted in treatment failures, increased mortality and significant healthcare costs [4,5]. The prevalence of resistance across a range of bacteria is high in Asia and specifically in South Korea [6]. According to an economic evaluation of AMR associated with meticillin-resistant *Staphylococcus aureus* (MRSA), implemented by the Korea Institute for Health and Social Affairs in 2006, the duration of hospital stay and the medical costs associated with AMR increased 1.8-fold and 1.25-fold, respectively [7]. The USA estimates the annual economic cost of AMR to be US$60 billion [8]. The World Health Organization (WHO) has repeatedly stated concerns about the increasing current and future threat posed by AMR and has strongly recommended strategic national and international approaches for AMR management [9,10].

In 2014, through the 67th World Health Assembly, the WHO emphasised the importance of the specific global action plans for AMR and presented a guideline of AMR control [11,12]. The USA and UK have already established strategies for AMR as well as initiatives on nationwide management [13–15].

AMR is increasing in South Korea. Since 2007, from the initiation of national surveillance programmes related to AMR, the prevalence of oxacillin-resistant *S. aureus* is consistently around 60%. Imipenem-resistant *Acinetobacter baumannii* increased from 20% to 62%, and imipenem-resistant *Pseudomonas aeruginosa* also increased from 26% to 42% [16]. Furthermore, South Korea continuously receives significant numbers of medical tourists from neighbouring countries, including China, where emerging issues related to AMR

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continue to cause serious concerns [17,18]. There is also noted widespread AMR across other Asian countries [19]. South Korea is a member of the G20 countries and has the 13th largest economy in the world [20]. In 2013, Korean research and development expenditure was 4.1% of the country's overall gross domestic product (GDP), second only to Israel and significantly higher than other developed countries such as the USA, UK, Germany and China [21]. Thus, how South Korea invests its research budgets is of great importance, not just for public health in South Korea but potentially for the global health community as well. It is imperative that distribution of limited resources uses strategic and smart approaches.

From 2003 to 2013, South Korea implemented a National Antimicrobial Resistance Safety Control Program (NARSCP), which was led by the Ministry of Food and Drug Safety (MFDS), the Ministry of Health and Welfare (MoHW) and the Korea Centers for Disease Control (KCDC) [22]. The first NARSCP, conducted from 2003 to 2007, was organised by the MFDS. During the second NARSCP, conducted from 2008 to 2013, the human health sector was organised by the MoHW and KCDC, and the veterinary health sector was organised by the MFDS [23].

There have been previous studies investigating research investments for AMR in the UK and across Europe [24,25]. This is the first study to describe the research investments related to AMR from the Korean funders (MFDS, MoHW and KCDC), which implemented NARSCP from 2003 to 2013 inclusive. We describe trends in total investment and across different types of research and also suggest future national and international research priorities.

2. Materials and methods

2.1. Data sources

This study collected award information through: (i) searching AMR-related research reports with keywords (antibiotics, antimicrobials, resistance, nosocomial infection and infection control) in the database of Policy Research Information Service & Management (http://www.prism.go.kr), the MFDS research management system (http://rnd.mfds.go.kr), electronic libraries of the National Center for Medical Information and Knowledge (http://library.nih.go.kr) and the National Assembly Library (http://nanet.go.kr); (ii) requesting award data from the policy-related divisions of the research aid institutions; and (iii) requesting award data directly from Korean research institutions. All award amounts were adjusted for inflation and are reported in 2013 US$. This study excluded AMR relating to viruses and parasites. Furthermore, tuberculosis was also excluded because this is covered by the Korean National Tuberculosis Control Program (ongoing since 1965 and data were not immediately available for analysis here), and thus NARSCP did not include projects directly related tuberculosis [26]. This study also excluded awards for research meeting support such as AMR-related academic symposiums.

2.2. Categorisation of awards

Categorisation was carried out by three authors (SHR, JCH and EHC) by reading the title and abstract of each award. Research awards were allocated to any of five categories used by the WHO's AMR action plan (awareness improvement, basic microbial research and surveillance, infection control, optimal use of antibiotics, and economic evaluation). In addition, awards were also categorised according to their type of science along the research pipeline. Categories were replicated from those used by the Research Investments in Global Health study [pre-clinical, clinical (phase 1, 2 or 3), product development, and implementation and operational research (including infection disease surveillance and epidemiology)] [27]. Statistical analysis was conducted using PASW Statistics for Windows v.18.0 (SPSS Inc., Chicago, IL).

3. Result

During the study period (2003–2013), the MFDS, MoHW and KCDC supported a total of 198 research projects, with a total investment of $18.3 million. Mean funding per award was $92,750 (SD $72,126), with a median of $71,714 (interquartile range $44,377–119,750). Considering the awards according to the five categories suggested by the WHO's AMR action plan, 143 (72.2%) were categorised as basic microbial research and surveillance, with a total investment of $14.1 million (76.8% of all investment) (Table 1). There was only one study in 2006, receiving $64,002 (0.3% of all investment), that focused on economic evaluation of AMR.

Temporal trends showed that total annual investment and individual award size broadly increased over the study period, from $961,476 (10 projects, mean award $96,147) in 2003 to $1,553,294 (14 projects, mean award $110,949) in 2013 (Fig. 1A). The proportion of research awarded by categories from WHO showed that most projects were focused on basic microbial research and surveillance (Fig. 1B).

Among the total 143 projects in the basic microbial research and surveillance category, pre-clinical research recorded 54 awards (37.8%) with total funding of $4,116,027 ($60,560 mean award), product development research recorded 1 award with total funding of $53,888, and operational research recorded 88 awards (61.5%) with total funding of $9,939,360 ($92,807 mean award). The distribution of the research pipeline was remained similar over the study period (Fig. 2). Within the operational research category, there were 10 projects related to awareness improvement (of which 2 had a physician-related focus and 8 focused on awareness in the community), 33 for infection control, 11 for optimal use of antibiotics (of which 8 had a focus on physicians in hospitals and 3 focused on antibiotic use in the community) and 1 for economic evaluation.

By receiving research institution, academia (such as universities and academic societies) received 145 awards (73.2%) with total funding of $12,546,019 (68.3% of all investment) and public

Table 1
Investment in antimicrobial resistance (AMR) by the number, total investment, and mean and median awards by categories from the World Health Organization (WHO).

Type	No. of awards	Proportion (%)	Total investment (US$)	Proportion (%)	Mean award (SD)	Median award (IQR)
Awareness improvement	10	5.1	592,208	3.2	5,922,075 (46,421)	42,620 (30,102–60,726)
Basic microbial research and surveillance	143	72.2	14,109,276	76.8	98,666 (66,791)	78,270 (52,991–127,152)
Infection control	33	16.7	2,592,845	14.1	78,571 (87,011)	38,146 (28,999–98,054)
Optimal use of antibiotics	11	5.6	1,006,208	5.5	91,473 (102,937)	62,368 (36,389–89,104)
Economic evaluation	1	0.5	64,003	0.4	64,003	64,003
Total	198	100	18,364,539	100	92,750 (72,126)	71,714 (44,377–119,750)

SD, standard deviation; IQR, interquartile range.