

National Strategic Action Plan on Antimicrobial Resistance

Singapore

Progress Report 2018-2020

One Health Antimicrobial Resistance Work Group

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A Report of the One Health Antimicrobial Work Group, jointly published by:

- Ministry of Health (MOH)
- Health Promotion Board (HPB)
- National Environment Agency (NEA)
- National Parks Board (NParks)
- PUB, Singapore's National Water Agency (PUB)
- Singapore Food Agency (SFA)

Supported by Antimicrobial Resistance Coordinating Office (AMRCO) at the National Centre for Infectious Diseases (NCID).



LIST OF ABBREVIATIONS

ACCSQ	ASEAN Consultative Committee on Standards and Quality
ACE	Agency for Care Effectiveness
ALD	ASEAN Leaders' Declaration
AMR	Antimicrobial Resistance
AMRCO	Antimicrobial Resistance Coordinating Office
AMS	ASEAN Member States
AMU	Antimicrobial utilisation
ASEAN	Association of South East Asian Nations
ASOEN	ASEAN Cooperation on Environment
ATLASS	Assessment Tool for laboratories and Antimicrobial resistance Surveillance System
AVA	Agri-food & Veterinary Authority
AVS	Animal & Veterinary Services
CAVS	Centre for Animal & Veterinary Sciences, NParks/AVS
CDC	Centers for Disease Control and Prevention, USA
CDD	Communicable Diseases Division, MOH
CLSI	Clinical and Laboratory Standards Institute
CoSTAR-HF	Collaborative Solutions Targeting Antimicrobial Resistance Threats in the Health Systems
CPE	Carbapenemase-producing Enterobacterales
ESBL	Extended Spectrum Beta-Lactamase
FAO	Food and Agriculture Organization of the United Nations
GAP-FF	Good Aquaculture Practices for Fish Farming
GLASS	Global Antimicrobial Resistance Surveillance System
GP	General Practitioner
HPB	Health Promotion Board
IDRTO	Infectious Disease Research & Training Office
IPC	Infection and Prevention Control
JEE	Joint External Evaluation
MOE	Ministry of Education
MOH	Ministry of Health
MRSA	Methicillin-resistant <i>Staphylococcus aureus</i>
NARCC	National Antimicrobial Resistance Control Committee
NAREP	National Antimicrobial Resistance Expert Panel
NASEP	National Antimicrobial Stewardship Expert Panel
NCID	National Centre for Infectious Diseases
NEA	National Environment Agency
NIPC	National Infection Prevention Committee
NMRC	National Medical Research Council
NRF	National Research Foundation
NSAP	National Strategic Action Plan
NTU	Nanyang Technological Institute
NUHS	National University Health System
NUS	National University of Singapore
OHARP	One Health AMR Research Programme

OIE	World Organisation for Animal Health
PUB	Singapore's National Water Agency
SFA	Singapore Food Agency
SGH	Singapore General Hospital
SIN-US TCTP	Singapore-United States Third Country Training Programme
SLS	Student Learning Space
SMART	Singapore-MIT Alliance for Research & Technology
SOM-AMAF	Senior Officials Meeting - ASEAN Ministers for Agriculture and Forestry
SOMHD	Senior Officials Meeting - Health Division
SQES	Singapore Quality Egg Scheme
SSHSPH	Saw Swee Hock School of Public Health, NUS
SVA	Singapore Veterinary Association
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
WAAW	World Antimicrobial Awareness Week
WE&RF	Water Environment & Reuse Foundation
WHO	World Health Organization
WPRACSS	Western Pacific Region Antimicrobial Consumption Surveillance System

INTRODUCTION

As microbes become increasingly resistant to antimicrobial agents, our ability to treat infections becomes correspondingly compromised, negating the benefits achieved by advances in modern medicine. Prolonged illnesses and increased mortality resulting from infections caused by drug-resistant organisms has been shown worldwide to lead to decreased productivity, higher treatment costs, and economic losses. It is currently estimated that resistant microbes cause 700,000 deaths worldwide and will overtake cancer as the leading cause of death by 2050 if no action is taken to reverse the trend of increasing antimicrobial resistance (AMR)¹.

The negative impact of AMR is not confined to human health. AMR threatens the health of animals and the environment, as well as the safety and security of our food and water. Diseases that affect animal husbandry and food production, contamination of water sources and the environment from run-offs, as well as improper disposal of antimicrobials, all affect access to safe food and water.

Singapore is a net importing country as well as a major global trade and tourist hub, and attracts a sizeable number of medical tourists. Agriculture is limited, and over 90% of food is imported from some 170 countries. Imported food and international travel may introduce new resistance determinants, while several potential pathways exist for local transmission within and between sectors (Figure 1). Our strategies therefore encompass domestic interests and international concerns, adopting both One Health and One World concepts.

¹ O'Neill, J. (2014). Antimicrobial Resistance: tackling a crisis for the health and wealth of nations. The Review on Antimicrobial Resistance. <https://amr-review.org>

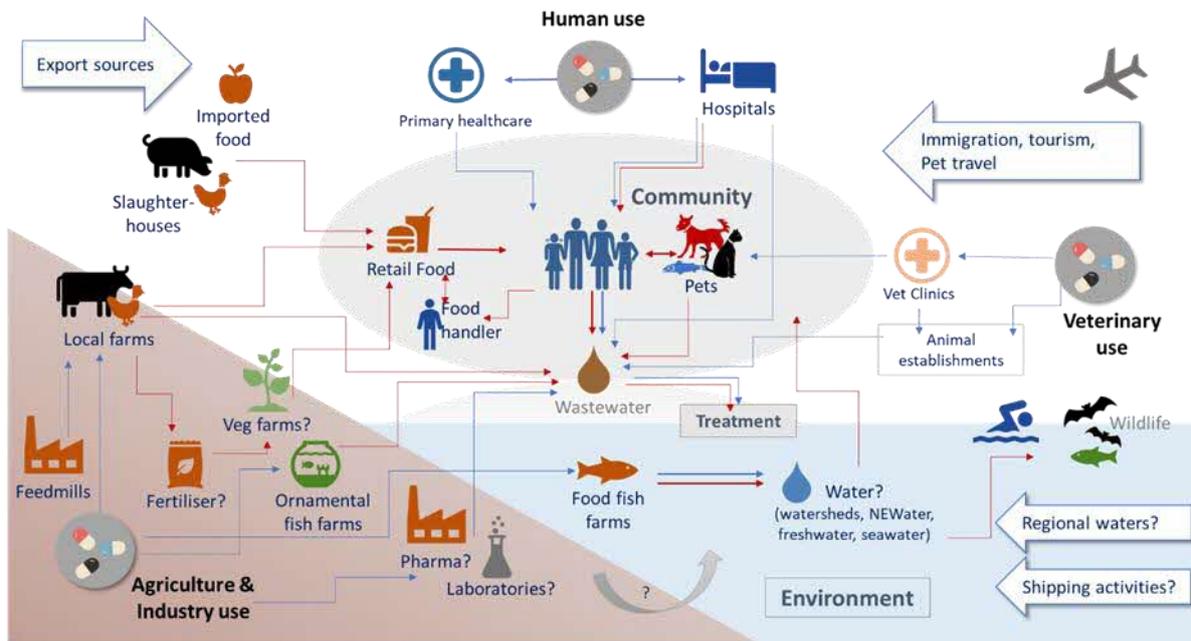


Figure 1. Antimicrobial use and potential pathways for the transmission of antimicrobial resistant organisms in Singapore. Pathways shown have been simplified for illustration purposes and may not cover all potential routes. Blue lines denote antimicrobial use pathways; red lines denote potential antimicrobial resistance pathways. (?) denotes areas of uncertainty concerning their role in AMR transmission.

The main drivers of AMR and its transmission are the overuse and inappropriate use of antimicrobials which contribute towards antimicrobial selection pressure. Global and national efforts are therefore targeted at reducing inappropriate use, improving infection control to reduce transmission and educating users and prescribers. These efforts are further supported by legislative controls, together with research and surveillance to provide the evidence base for risk assessment and policy development.

On 1 November 2017, the One Health AMR Work Group launched Singapore’s National Strategic Action Plan (NSAP) on AMR, bringing together and building on existing efforts in the human, animal, food and environment sectors. The NSAP aims to reduce the emergence and prevent the spread of drug-resistant organisms through 5 core strategies: (i) Education; (ii) Surveillance and Risk Assessment; (iii) Research; (iv) Prevention and Control of Infection; and (v) Optimisation of Antimicrobial Use. These core strategies are further underpinned by the principles of international collaboration and economic sustainability. Singapore’s NSAP can be found at

<https://www.ncid.sg/About-NCID/OurDepartments/Antimicrobial-Resistance-Coordinating-Office/Documents/National%20Strategic%20Action%20Plan%20on%20Antimicrobial%20Resistance.pdf>.

Today, the One Health AMR Work Group is comprised of representatives of the Ministry of Health (MOH), Health Promotion Board (HPB), the National Environment Agency (NEA), the National Parks Board (NParks), PUB, Singapore’s National Water Agency (PUB), the Singapore Food Agency (SFA), and is supported by the AMR Coordinating Office (AMRCO) of the National Centre for Infectious Diseases (NCID) (Figure 2).

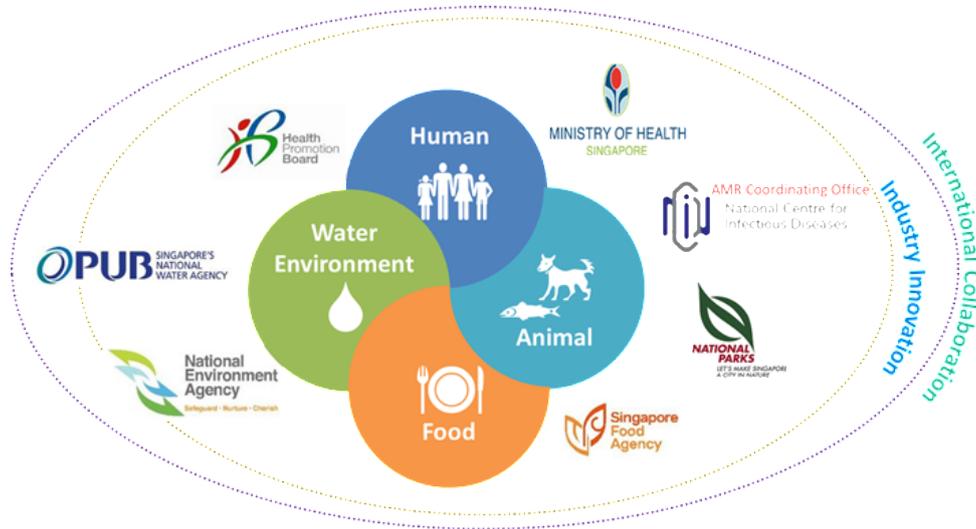


Figure 2. The National Strategic Action Plan is a collaborative effort of agencies in the human, animal, food and environment sectors to combat the threat of AMR.

Beyond the Work Group, the One Health ministries and agencies collaborate with their partners and stakeholders to drive AMR efforts in the respective sectors. This includes other government bodies, healthcare institutions, institutes for higher learning, pharmaceutical companies, professional associations, veterinary clinics, farms, industry, as well as among countries of the Association of Southeast Asian Nations (ASEAN) and international organisations, such as the Food and Agriculture Organization (FAO) of the United Nations, World Organisation for Animal Health (OIE), the World Health Organization (WHO) and the United Nations Environmental Programme (UNEP).

This Report describes the progress of implementation of the NSAP by national bodies in the three years since its launch, the challenges faced and our next steps forward. It must be stressed that this report does not attempt to capture the full range of equally important work in Singapore, including among others, on-going research and training by institutes of higher learning and scientific institutions, the contribution of professional associations and efforts in the private sector.

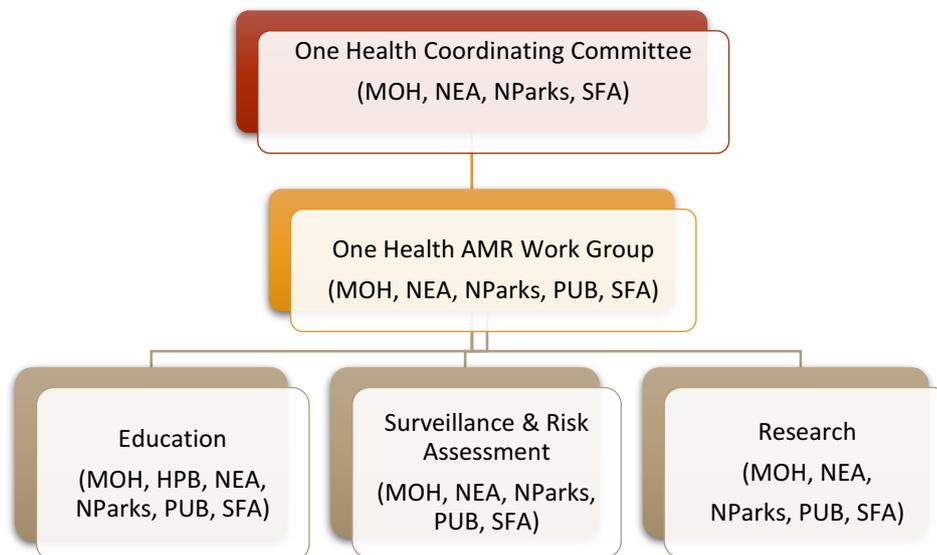
ONE HEALTH COORDINATION

One Health Structure in Singapore

The “One Health” concept recognises the inter-relationship between human, animal, food, and environmental health. The **One Health approach** has been described as a “collaborative, multisectoral, and trans-disciplinary approach – working at local, regional, national and global levels – to achieve optimal health and well-bring outcomes recognising the interconnections between people, animals, plants and their shared environment.”²

A One Health structure, helmed by a One Health Coordinating Committee, has been in place in Singapore since 2011 to provide strategic direction and set priorities for One Health issues, including, but not limited to, zoonoses and foodborne diseases. Reporting to the One Health Coordinating Committee, the One Health AMR Work Group works to recommend One Health policies and strategies to control AMR and ensure a coordinated and unified response among the different sectors. Three technical sub-working groups were also established to focus on cross-sectoral coordination of education, surveillance and risk assessment, and research activities relevant to AMR.

Figure 3. One Health structure for AMR Coordination



² One Health Commission. https://www.onehealthcommission.org/en/why_one_health/what_is_one_health/

Implementation Progress

- **Establishment of a national coordinating body for AMR.** The Antimicrobial Resistance Coordinating Office (AMRCO) was established in 2018 by the MOH, under the National Centre for Infectious Diseases (NCID), to support the national AMR agenda. The AMRCO serves as the national coordinating centre to oversee the implementation, monitoring and evaluation of the NSAP. This is achieved through the engagement of the One Health agencies, as well as other government bodies and stakeholders to facilitate and coordinate AMR efforts across human, environmental, food and animal sectors. AMRCO also serves as the secretariat for the national AMR committees and expert panels, which includes the One Health AMR Work Group, the National AMR Control Committee (NARCC) and its advisory panels, the National Antimicrobial Stewardship Expert Panel (NASEP) and the National Antimicrobial Resistance Expert Panel (NAREP).
- **Development of a 5-year One Health AMR work plan, 2018 - 2022.** Since the launch of the NSAP, a combined 5-year work plan has been developed to achieve the objectives of the core strategies. This national work plan details specific programmes and activities that will be carried out by One Health agencies in implementing the NSAP initiatives across the various sectors. These include:
 - Raising awareness among members of the public, pet owners and industry players on the appropriate use of antibiotics;
 - Expanding the breadth of surveillance for antibiotic-resistant bacteria and antimicrobial utilisation in the community, in animals and the shared environment;
 - Developing national guidelines for appropriate antimicrobial use, vaccination and improved infection control in human and animal healthcare settings; and
 - Strengthening and supporting One Health AMR research.

A monitoring framework was also developed to track the progress of implementation and outcomes of the NSAP, adopting monitoring indicators³ recommended by the Tripartite organisations (FAO, OIE and WHO) where appropriate.

³ FAO, OIE, WHO. Monitoring and Evaluation of the Global Action Plan on Antimicrobial Resistance – Framework and recommended indicators. May 2019. www.who.int

CORE STRATEGY 01: EDUCATION

Education is aimed at raising the awareness and understanding of the public, professionals and industry, through effective communication, education and training. Education on AMR and the appropriate use of antimicrobials is an important first step towards behaviour change, with the aim of reducing behaviours that exacerbate the development and spread of resistant organisms.

Priority areas identified in the NSAP include:

- Increasing public awareness and understanding of AMR and the importance of using antibiotics appropriately; and
- Strengthening education initiatives for professionals across human and animal health.

Key achievements and Implementation Progress

Public Education

- **Public education campaign.** Starting in 2018, the HPB rolled out a campaign to increase awareness on the right use of antibiotics and the harmful consequences of antimicrobial resistance. HPB launched its “Use Antibiotics Right” campaign in October 2018 featuring the ‘Mr Pill’ to spread the key message: “Antibiotics do not work on the flu virus”. A survey by the Saw Swee Hock School of Public Health at the National University of Singapore (NUS SSHSPH) in 2015 had found that 78% of respondents were of the view that antibiotics are effective against viruses⁴ Furthermore, it also found that about 30% of patients seeing a doctor expected antibiotics, of which one-third of these would see another doctor if antibiotics are not prescribed. Educating the public that antibiotics do not treat the flu virus and to take antibiotics only upon a doctor’s advice, was a way to decrease patient demand for or expectation of an antibiotic prescription. HPB’s 2019 campaign built on 2018’s message to address a common misconception that antibiotics could help one recover more quickly from the flu. Hence the message “Antibiotics will not help you recover faster from the flu as they don’t work on the flu virus”. More information on HPB’s campaign can be found at <https://www.healthhub.sg/antibiotics>. In 2019, HPB, in collaboration with AMRCO, developed a general practitioner (GP) resource and patient brochure to aid physicians in educating their patients on when antibiotics are needed, side-effects of antibiotics

⁴ Pan et al, 2016. Knowledge, attitudes and practices towards antibiotic use in upper respiratory tract infections among patients seeking primary health care in Singapore. BMC Family Practice 17:148

and the part they play in preventing AMR. These AMR resources have been distributed nationwide to polyclinics and private GP clinics throughout Singapore.

To complement national efforts to tackle AMR by preventing spread of infections, HPB ramped up communication efforts through its hygiene education campaigns. Messages on handwashing were disseminated across various touchpoints to maintain top-of-mind awareness and promote good hand hygiene practices. More information on HPB's hand hygiene campaign can be found at <http://www.healthhub.sg/staywell>.

- **Outreach to library-goers during the World Antimicrobial Awareness Week (WAAW).** The NUS Saw Swee Hock School of Public Health (SSHSPH) reprised their public engagement event at the Jurong Regional Library during WAAW 2018 and 2019. Held annually since 2016, these events aim primarily to teach young children about germs and antibiotics and how they can help counter the problem of antibiotic resistance through hygiene (handwashing), vaccination and listening to the doctor's or vet's advice on antibiotic use. The most recent event was held at the Jurong and Woodlands Regional libraries over two weekends in November 2019, and with the launch of "The Antibiotic Tales" comic by Sonny Liew and Dr Hsu Li Yang (below) occurring in Jurong Regional Library. The events attracted a total of 1500 children and adults. The events also involved volunteers from NUS, MOH, NParks, SFA, NCID, Ngee Ann Polytechnic, Temasek Polytechnic, Singapore American School and public hospitals. More information on this event can be found at <https://blog.nus.edu.sg>. Due to the COVID-19 pandemic, there was no event in 2020.
- **Launch of "The Antibiotic Tales" comic and video.** SSHSPH collaborated with award-winning comic artist to develop a comic book for raising public awareness of AMR. This was published by Epigram Books in 2019, and endorsed by WHO Director-General Dr Tedros Adhanom Ghebreyesus. In 2020, part of the comic was animated by animation company Finding Pictures (<https://www.finding.pictures/#/world-antibiotics-awareness-week>), and launched for WAAW 2020. This was featured by WPRO at their virtual rally "Stewards for the future: One Region, One Movement to fight Antimicrobial Resistance" on 27th November 2020.
- **Student education.** The Ministry of Education (MOE), in collaboration with the NCID, produced a video on AMR for MOE's Student Learning Space (SLS), which is an online portal directed at MOE students to facilitate self-directed learning. The video featured an Infectious Disease physician who addressed common misconceptions concerning the use of antibiotics and provided advice on ways to prevent the rise of AMR. It was targeted as an optional resource for the Singapore-Cambridge General Certificate of

Education Advanced Level (GCE A Level) Biology students, and was made available to all students on the SLS site in 2019.

- **Reinforcing food safety and hygiene.** In 2018, the former Agri-food and Veterinary Authority (AVA)⁵ introduced the concept of “Germs in food can make you sick” into food safety campaigns targeted at kindergarten and lower primary schools. This message aimed to have young children understand basic ideas of how one gets food-poisoning and the importance of hygiene and safe food practices in preventing foodborne infections. The newly-formed SFA continued with the efforts to educate and engage the public on food safety. In 2019, SFA launched a webpage on its website, providing information on AMR and what the stakeholders can do to combat AMR collectively. In the same year, SFA released an animation video on AMR, titled “The Rise of Superbugs” on both the SFA website and social media platforms, in conjunction with WAAW, to promote public awareness of AMR from food and mitigation through proper food safety practices. The video may be accessed through this QR code. More information on SFA’s food safety public education programmes and AMR can be found at <https://www.sfa.gov.sg/food-information/food-safety-education/food-safety-a-joint-responsibility> and <https://www.sfa.gov.sg/food-information/food-safety-education/antimicrobial-resistance> respectively.
- 
- **Outreach to pet owners.** Starting from 2019, NParks incorporated educational messages into their monthly Pets’ Day Out event and regular online webinars, aimed at pet owners, animal-related businesses and animal enthusiasts. These messages highlighted the importance of vaccinations, impact of AMR on animal health and raised awareness on practical measures (e.g. good husbandry) that pet owners and animal carers can take to reduce AMR spread. These were also shared with the wider pet community through NParks’ social media platforms – AnimalBuzzSG. Information for pet owners on antimicrobial resistance can be found at <https://www.nparks.gov.sg/avs/animals/animal-health-and-veterinarians/animal-diseases-and-antimicrobial-resistance/antimicrobial-resistance>.

⁵ On 1 April 2019, the Agri-Food and Veterinary Authority (AVA) was restructured into the Singapore Food Agency (SFA) and the Animal & Veterinary Service of National Parks Board (NParks/AVS). SFA continues the current work on the food-related aspects of AMR, while NParks/AVS will focus on the animal health-related aspects of AMR.

Professional Education

- **Healthcare professionals.** AMRCO in collaboration with the Infectious Disease Research and Training Office (IDRTO), NCID jointly organised education initiatives to increase awareness of AMR amongst healthcare professionals. On 23 February 2019, more than 175 general practitioners and family physicians from polyclinics and GP clinics island-wide attended a Primary Care Forum (PCF), which introduced best practices in the management of common infections, such as urinary tract infections. On 7 and 21 November 2020, the 2nd edition of the PCF engaged a total of 425 healthcare professionals across the hospital and community settings through a series of talks to address appropriate prescribing practices for common infections. In particular, the role of vaccination in reducing AMR was also emphasised as it reduces the risk of infection and thus the need for antibiotics.
- **Commemorating WAAW at all ten public healthcare institutions.** Since 2015, public hospitals progressively started conducting activities to commemorate WAAW yearly in November. Targeted at both the public and healthcare professionals they aim to raise awareness about AMR and promote best practices. For WAAW 2019, public hospitals adopted a unified WAAW messaging for healthcare professionals and promoted HPB's national AMR campaign messages for the public. The key messages for healthcare providers were to: "Only prescribe and dispense antibiotics when needed for certain bacterial infections, in accordance with current therapeutic guidelines; and where possible, use diagnostics to make informed prescribing decisions", and "Educate patients on the importance of appropriate antibiotic use and provide them with advice on how their symptoms could be managed without the use of antibiotics." For WAAW 2020, public hospitals, with support from AMRCO, jointly organised the first WAAW Inter-Hospital Webinar Series on AMR. A total of six lunchtime talks were held for healthcare professionals on antimicrobial stewardship, vaccination and AMR. In addition, a social media campaign themed around AMR and vaccinations was launched on PHIs' social media accounts, together with the launch of the animated video adapted from the "The Antibiotic Tales" comic.
- **Veterinary professionals.** NParks has been incorporating AMR topics into the licensing briefings conducted for veterinarians since 2019. Attendance of these briefings is mandatory for veterinarians in Singapore to maintain their licenses. NParks worked with the Singapore Veterinary Association to offer continuing professional education on AMR topics in 2020. AMR articles were also shared in the quarterly newsletter sent out to all registered veterinarians in 2019, encouraging antimicrobial stewardship and providing practicable suggestions for infection control in veterinary centres.

- **Pre-service veterinary education.** In 2019, NParks began collaborations with local polytechnics to incorporate AMR topics into the curricula of veterinary diploma courses, and to mentor veterinary diploma students in projects related to surveillance and raising awareness on AMR. The projects started in 2020 and include surveys of veterinary clinics, and designing educational materials such as videos and brochures for pet owners on AMR and vaccination.

Industry Outreach

- **Farmer engagement.** To ensure that antibiotic growth promoters are not used in Singapore's farms, a directive was issued by the former AVA in November 2018 to explicitly prohibit the use of antibiotics for growth promotion in livestock and aquaculture. In addition, the directive also added to the existing list of banned drugs which includes certain antibiotics that are critical to human health, antibiotics such as carbapenems and colistin, which are deemed drugs of last resort when other antibiotics fail to work. As part of SFA's activities to raise awareness of antibiotic resistance in the livestock sector, and in conjunction with WAAW in 2019, SFA reviewed and further expanded the list of banned drugs in the 2018 directive. Updated directives issued by SFA reiterated the importance of AMR and reminded stakeholders of the prudent use of antimicrobials. The directive also ensured that antimicrobials were not allowed for non-veterinary medical use such as for promoting the growth of food-producing animals.

Moving ahead

- We will continue expanding AMR education efforts in the community, building on key messages from the current public campaign, and harmonising key messaging across the public, healthcare, veterinary and agriculture sectors;
- Further opportunities for enhancing the knowledge of professionals in human and animal health through continuing professional education initiatives will be identified and conducted;
- AMR-related curriculum and knowledge in relevant diploma, undergraduate and postgraduate education for healthcare and veterinary professionals are being mapped, and will be enhanced where necessary.

CORE STRATEGY 02: SURVEILLANCE AND RISK ASSESSMENT

A nationally coordinated surveillance of AMR and antimicrobial utilisation (AMU) is essential to understand the magnitude, distribution and impact of resistant organisms and antimicrobial usage. Monitoring and surveillance will also enable us to identify emerging resistance and trends, determine associations between usage and resistance, and measure outcomes of policies and initiatives to control AMR. Surveillance also provides data for risk assessment, to enable an appropriate response to be mounted and identify where resources should be targeted.

Some of the priority areas for further action identified in the NSAP include:

- Integrating surveillance across human, animals, food and environment sectors;
- Publishing and reporting relevant surveillance data at the national, regional and international levels;
- Extending surveillance to cover private hospitals; and
- Expanding AMR surveillance to all animal production sectors.

Key Achievements and Implementation Progress

- **First One Health report on AMR surveillance and antimicrobial utilisation in Singapore.** Prior to the establishment of the NSAP, surveillance was conducted and reported independently by different ministries and agencies for their respective sectors. A key initiative of the NSAP for AMR was to unify these existing independent efforts. This multi-sectoral report provided an overview of the main national surveillance activities conducted in the human, animal, food and water environment sectors up to 2017. This report represents an important first step towards a more integrated surveillance system for antimicrobial resistance and utilisation in Singapore. In general, the report found that target organisms and antimicrobials differed from sector to sector, based on the priorities of each sector. However, several common concerns, such as methicillin-resistant *Staphylococcus aureus* (MRSA) and extended spectrum beta-lactamase (ESBL)-producing *Escherichia coli* (*E. coli*) present potential areas for deeper collaboration. One gap identified was the lack of data on antibiotic consumption in the community; this is an area that needs to be addressed in stages. The full report can be found at <https://www.ncid.sg/About-NCID/OurDepartments/Antimicrobial-Resistance-Coordinating-Office/Documents/One%20Health%20Report%20on%20Antimicrobial%20Utilisation%20and%20Resistance%202017.pdf>
- **Enrolment in the WHO Global Antimicrobial Resistance Surveillance System (GLASS).** Singapore enrolled in GLASS in September 2019. GLASS was established by the WHO

in 2015 for worldwide AMR data collection and sharing, with the aim to enable standardised and comparable data on AMR in the human health sector to be collected, analysed and shared with all countries and partners. This allows WHO and its Member States to better understand global AMR trends, and to formulate measures to address AMR. GLASS collects aggregated country data on four priority specimens (blood, stool, urine and genital swab samples) and eight organisms (*E. coli*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Salmonella* spp., *Shigella* spp., *Neisseria gonorrhoeae*), stratified by age group, gender, and onset (hospital vs community) wherever possible. Singapore submitted aggregated data from 2 sentinel hospitals and 1 sentinel outpatient site in 2020. Country data and more information on GLASS can be found at www.who.int/glass.

- **Enrolment in the WHO Western Pacific Regional Antimicrobial Consumption Surveillance System (WPRACSS).** Singapore enrolled to the WHO Western Pacific Regional Antimicrobial Consumption Surveillance System (WPRACSS) in 2019 to contribute national data on antimicrobial consumption. WPRACSS aims to build capacity for antimicrobial consumption monitoring in countries, which will ultimately contribute to the regional database. A web-based regional database as the basis for regional analysis and technical advice to countries is being developed. Singapore submitted aggregated data from the public hospitals in 2020.
- **Expansion of AMR and AMU surveillance to private hospitals.** AMR and AMU data in acute care public hospitals have been regularly monitored and reported to MOH through NARCC since 2011. Following a series of engagement, AMR and AMU surveillance started including data from private hospitals from 2018. Indicators reported include detection rates of resistant organisms in hospitals, such as carbapenemase-producing Enterobacterales (CPE) and *Clostridioides difficile* (*C. difficile*), as well as utilisation of important antibiotic classes, such as fluoroquinolones, cephalosporins, penicillins and carbapenems. The first analysis of private hospital data was shared with hospital management in 2020 to bring to their awareness the baseline rates, facilitate discussions on improving antimicrobial prescribing and enhance surveillance for key AMR trends.
- **Expansion of AMR and AMU surveillance to primary care.** AMRCO initiated AMU surveillance efforts among the polyclinics in 2018, and in 2020, further expanded AMR and AMU surveillance efforts into the primary care sector through two pilots – an AMU surveillance pilot of sentinel private GP clinics and AMR surveillance pilot in the polyclinics. The collection of surveillance data facilitates the monitoring and trending of antibiotic usage and resistance data in primary care, and provides a useful baseline for the assessment and measurement of outcomes for interventions, such as educational campaigns to address the inappropriate use of antibiotics.

- **Expansion of AMR surveillance to all terrestrial livestock farms.** Prior to the development of the NSAP, AMR surveillance was limited only to drug-resistant *Salmonella enterica* ser Enteritidis (*S. Enteritidis*) in chicken layer farms. In November 2017, the former AVA expanded the AMR surveillance to include all *Salmonella* spp. as well as indicator *E. coli*, covering all terrestrial livestock farms in Singapore. This includes three chicken layer farms, two quail layer farms, three dairy cattle farms and one dairy goat farm.
- **Harmonisation of antibiotic susceptibility test methods between national food and animal laboratories.** Standardised test methods for surveillance allow for comparability of antibiotic susceptibility of bacteria found in food products and food-producing animals. In 2018, the Veterinary Public Health Centre (now known as National Centre for Food Science, SFA) and the Animal Health Laboratory (now the Centre for Animal & Veterinary Sciences, NParks) agreed to adopt common methods for measuring minimum inhibitory concentration using a common panel of antibiotics for surveillance and interpretative breakpoints established by the Clinical & Laboratory Standards Institute (CLSI).
- **Annual data collection and reporting of antimicrobial agents intended for animal use to OIE.** Since 2015, the former AVA had been collating and reporting antimicrobial sales data from wholesalers annually to OIE, the World Organisation for Animal Health. Antimicrobial sales data is now compiled and reported by NParks. The response from wholesalers increased significantly in 2020, with about 92% of wholesalers submitting their sales data to NParks, up from 52% in 2015. Collection of antimicrobial sales data serves as a proxy for utilisation and enables NParks to monitor trends in antimicrobial consumption in various animal sectors in Singapore.
- **Establishing AMR surveillance programmes for environmental sectors.** Surveillance approaches have been developed to understand the prevalence of AMR in different environmental matrices such as air, surfaces and water. A preliminary study on the risk assessment of AMR in water and wastewater has been conducted by PUB. Ongoing studies in coastal sites and associated water bodies are being conducted by NEA.

Moving ahead

- The number of sentinel sites submitting data to WHO GLASS will be gradually expanded to improve the representation of Singapore's data;
- National antibiotic sales data will be explored as a proxy for national consumption;

- AMR surveillance will be expanded in phases to encompass target organisms in local food fish farms, wildlife, companion animals and community animals;
- Collected data from continued surveillance studies will be used for further risk assessment of AMR in the environment.

CORE STRATEGY 03: RESEARCH

Research helps to fill in important gaps in knowledge to improve our understanding of the AMR situation and enhance tools and measures needed to help control the problem. Priority areas identified in the NSAP that are being addressed include:

- Mapping of AMR research conducted in Singapore;
- Fostering multi-agency, multi-disciplinary and multi-sectorial research collaboration in AMR;
- Developing a national AMR research agenda and establish long-term funding for One Health research in AMR.

Key Achievements and Implementation Progress

- **Establishment of a national coordinating body.** The AMR Coordinating Office, established under the auspices of the NCID, serves as the national body to coordinate One Health AMR research across human, animal, food and environment sectors.
- **Engagement of professionals, academia and industry.** A One Health AMR research workshop organised by the One Health AMR Work Group on 22 September 2017 brought together some 50 participants from universities, research institutions, national laboratories, pharmaceutical and biomedical companies, from healthcare, veterinary, food and environment sectors. In breakout sessions, participants discussed Singapore's strengths in AMR management and the respective areas of AMR research; knowledge and research gaps specific to Singapore and priority areas for research. These inputs are being used to help build a national research agenda on AMR.
- **Mapping the AMR research landscape in Singapore.** This is an on-going effort to understand the AMR research landscape, past and on-going work, as well as future directions of AMR research. A database of past and on-going research carried out by Singapore researchers across sectors is being established. Overall, this effort would support the development of the national research agenda for AMR, identify the domain experts, improve utilisation of resources and providing avenues for greater collaboration between disciplines and sectors. A list of scientific publications by local researchers and government agencies from 2018 to 2020 is presented in [Annex 1](#).
- **Funding AMR research.** Several nationally-funded programmes for AMR research in Singapore include:
 - The **Collaborative Solutions Targeting Antimicrobial Resistance Threats in the Health Systems (CoSTAR-HS)** was launched in August 2016, funded by the

National Medical Research Council (NMRC). It is a partnership involving researchers and clinicians from the National University Health System (NUHS), Singapore General Hospital (SGH) and Communicable Disease Centre (now NCID). CoSTAR-HS aims to build capacity, infrastructure and networking opportunities for AMR research in Singapore. In 2018 and 2019, two and four projects were awarded under this grant, encompassing projects such as developing peptide nanotechnology of antibiotic delivery, use of phages against carbapenem-resistant organisms and exploring new drug susceptibility testing and treatment strategies for non-tuberculosis mycobacterial infections. More information can be found at <https://sph.nus.edu.sg/research/costar-hs/>.

- **Antimicrobial Resistance Interdisciplinary Research Group (AMR IRG)**, formed by Singapore-MIT Alliance for Research & Technology (SMART), is a translational research and entrepreneurship programme funded by National Research Foundation (NRF) that tackles the growing threat of AMR. Launched in January 2018 for an initial period of five years, projects within the AMR IRG range from fundamental microbiology through the understanding of resistance mechanisms and host-pathogen relationships, to the development of novel diagnostics and therapeutics that can be progressed towards clinical translation. More information can be found at <https://amr.smart.mit.edu>.
- **One Health AMR Research Programme (OHARP)** is a grant established and funded by Singapore's One Health agencies, namely MOH, NEA, NParks, PUB and SFA. The Programme will support cross-sectoral AMR research in priority areas of national interest, namely in areas of (i) transmission pathways across sectors, (ii) knowledge, attitudes and practices of key players, and (iii) the socioeconomic impact of AMR in Singapore, with outcomes that will contribute towards informing policies, formulating interventions and guiding operations aimed at combatting AMR in Singapore. NCID has been appointed by MOH as the grant intermediary to administer the Programme. More information on the OHARP can be found at <https://www.ncid.sg/Health-Professionals/Pages/Grants-and-Fellowships.aspx>.

Moving ahead

- Based on a map of the AMR research landscape in Singapore, we aim to establish a national AMR research agenda, which will serve to focus and drive research activities in areas of importance;
- Additional sources of funding will be explored to sustain AMR research in the longer term.

CORE STRATEGY 04: PREVENTION AND CONTROL OF INFECTION

Better hygiene and infection prevention measures are essential to limit the development and spread of infectious agents as well as multidrug-resistant microorganisms. Effective infection prevention measures include proper sanitation, handwashing, food handling practices, farm biosecurity and good animal husbandry practices. Vaccination is another important tool for the prevention of infection, and can reduce antimicrobial resistance through:

- Preventing infectious diseases that would require antimicrobial medicines to treat;
- Reducing the prevalence of primary viral infections, such as influenza, which are often treated inappropriately with antibiotics, and can also give rise to secondary infections that require antibiotic treatment.

Priority areas that require action include:

- Enhancing infection prevention and control measures in hospitals;
- Increasing the uptake of vaccination in community and animals;
- Improving animal health management practices.

Key Achievements and Implementation Progress

In human health

- **Strengthening influenza and pneumococcal vaccination in the community.** The National Adult Immunisation Schedule (NAIS) was introduced in 2017 as a comprehensive framework for vaccine recommendations in adults. Funding mechanisms to support adult vaccinations, including influenza and pneumococcal vaccinations were further strengthened in November 2020, with all Singaporeans being provided with subsidies for medically indicated vaccines under NAIS, based on age and medical conditions.
- **Vaccination for foreign-born children applying for long-term immigration passes.** Under the Infectious Disease Act, diphtheria and measles vaccinations are mandatory for all Singapore-born children. Measles is caused by a virus, while diphtheria is caused by the bacterial microorganism *Corynebacterium diphtheriae*. It is a highly contagious bacterial infection of the nose and throat. In severe cases, diphtheria is fatal in 5 – 10%

of cases, with a higher mortality rate in young children⁶. Being a bacterial infection, antibiotics are needed to treat diphtheria. However, diphtheria is easily prevented with an effective vaccine. Children in Singapore are therefore required to be vaccinated by 1 year of age; however, unvaccinated foreign-born children were still at risk of contracting and spreading the infection. With effect from 1 February 2019, MOH requires parents of foreign-born children to provide documentation of diphtheria and measles vaccinations as a prerequisite for applying for long-term immigration passes in Singapore. Vaccination not only helps prevent infection and the spread of diphtheria, but reduces the use of antibiotics needed to treat the infection. More information can be found on HPB's National Immunisation Registry page on www.nir.hpb.gov.sg.

- **Staying ahead by getting vaccinated.** In November 2020, HPB launched the 'Stay One Step Ahead with Vaccinations' campaign to encourage Singaporeans to get vaccinated against vaccine-preventable diseases such as influenza and pneumococcal disease. The campaign also raised awareness of the Ministry of Health's roll-out of subsidies and greater accessibility of subsidised vaccinations for eligible Singaporeans at Community Health Assist Scheme (CHAS) General Practitioner clinics and polyclinics. More information on HPB's vaccination campaign can be found at HPB's www.healthhub.sg/vaccinate
- **Development of national infection control guidelines for healthcare facilities.** National Infection Prevention and Control (NIPC) Committee which comprises experts from the healthcare institutions is commissioned by MOH to develop the national infection prevention and control (IPC) strategy. This includes surveillance of disease outbreaks and healthcare associated infections (HAIs), and the development of IPC guidelines, standards and audit tools in consultation and collaboration with the IPC community in Singapore to meet national needs. The national IPC guidelines serve as a reference for healthcare professionals, management and operations staff working in healthcare facilities in Singapore. Previously developed documents include the *National IPC Guidelines for Acute Healthcare Facilities* which provided guidance on preventing and controlling infections and multi-drug resistant organisms. More recently, the *National Infection and Prevention Control Guidelines for Outpatient Dialysis Centres* and the *National Infection Prevention and Control Standards for Acute Healthcare Facilities* were developed to provide standards and recommendations for

⁶ Diphtheria, WHO, in <https://who.int/immunization/diseases/diphtheria/en/>

quality assurance and quality improvement mechanisms at healthcare facilities. The guideline and standards are found at:

- For outpatient dialysis centres- <https://www.moh.gov.sg/resources-statistics/guidelines/national-infection-prevention-and-control-guidelines-for-outpatient-dialysis-centres>
- For acute healthcare facilities- <https://www.moh.gov.sg/resources-statistics/guidelines/infection-control-guidelines/national-infection-prevention-and-control-guidelines-for-acute-healthcare-facilities>
- Earlier IPC guidelines can also be found at <https://ncid.sg/Health-Professionals/Pages/Infection-Control-Guidelines-for-Healthcare-Facilities.aspx>.

In animal health

- **Promoting good animal husbandry and good aquaculture practices to local farms.** SFA currently administers the Singapore Quality Eggs Scheme (SQES) and Good Agriculture Practice – Fish Farms (GAP-FF) certification schemes. The SQES standard stipulates farm management systems with good animal husbandry practices to ensure production of safe and quality shell eggs that are fresh. On the other hand, the GAP-FF stipulates farm management systems with good agricultural practices to ensure safe farm produce by local aquaculture farms both land-based and coastal. More information on SFA's SQES and GAP-FF can be found at <https://www.sfa.gov.sg/food-farming/farming-initiatives/singapore-quality-egg-scheme> and [https://www.sfa.gov.sg/food-farming/farming-initiatives/good-aquaculture-practices-for-fish-farming-\(gap-ff\)](https://www.sfa.gov.sg/food-farming/farming-initiatives/good-aquaculture-practices-for-fish-farming-(gap-ff)) respectively.
- **Launch of national vaccination guidelines for dogs and cats.** NParks set up a working group in 2019 with the Singapore Veterinary Association to research and publish guidelines for canine and feline vaccination. The guidelines are tailored to Singapore's context, and take into account unique factors such as the high population density and vibrant pet community locally. Recommendations on vaccination schedules, vaccine types, good practices and other evidence-backed information are detailed in the guidelines, which was published in November 2020. The guidelines may be found at https://sva.org.sg/wp-content/uploads/2020/11/Singapore-Vax_guidelines-version-final_FINAL.pdf
- **Development of national standard requirements and guidelines for use of autogenous vaccines.** Veterinary autogenous vaccines are vaccines prepared from cultures of microorganisms obtained from an affected animal or group of animals, which is then used to immunise the same animals against that microorganism.

Autogenous vaccines help fill the gap when commercial licensed vaccines are not available or have not yet been developed against a specific disease. Where disease is caused by a bacterial pathogen, bacterial autogenous vaccines help reduce the need for antibiotic treatment. In Singapore's context, they are particularly useful for controlling bacterial diseases of tropical food fish, for which few vaccines have been developed. However, there are no international standards for autogenous vaccines. National standards and guidelines for use have been developed by NParks; these aim to provide more clarity on regulatory requirements and hasten the process from development to application, to prevent further spread of disease.

Moving ahead

- Infection prevention and control guidelines for acute healthcare and long-term care facilities are being updated, with revisions to be published in 2021/2022;
- Additional guidelines are being developed by the NIPC to guide infection prevention and control practices for primary care and community hospitals;
- NParks is collaborating with SVA to develop guidelines on pet husbandry.

CORE STRATEGY 05: OPTIMISATION OF ANTIMICROBIAL USE

Optimisation of antimicrobials refers to the judicious and rational use of these important medicines, so as to limit the development of AMR and preserve the efficacy of antimicrobials for treating infections. One way to achieve this is through improving stewardship of antimicrobials and implementing policies that restrict the inappropriate and unnecessary use of antimicrobials, especially those which are critical to human and animal health.

Priority areas identified in the NSAP include:

- Strengthening antimicrobial stewardship in hospitals, and
- Strengthening the system to ensure prudent use of antimicrobials in veterinary medicine and reduce inappropriate use of antimicrobials in food-producing animals.

Key Achievements and Implementation Progress

In human health

- **Initiation of Antimicrobial Utilisation-Point Prevalence Survey (AMU-PPS) in public healthcare institutions.** Public hospitals in Singapore have been reporting to the NARCC two metrics to monitor the effectiveness of antimicrobial stewardship programme (ASP) in their respective hospitals since 2011. As the performance of hospital ASP has improved and stabilised over the years, AMU-PPS was initiated in 2020 as a supplementary surveillance and monitoring methodology. AMU-PPS will also help to identify and drive additional areas for ASP improvement. As of 2020, it will be conducted twice yearly in each public hospital and selected indicators, such as prevalence of antimicrobial prescriptions will be monitored.
- **The Singapore Antimicrobial Stewardship Training Course** is jointly organised by the NCID and partner hospitals, and conducted over 2 full days annually. This training course provides participants from Singapore and the region, with best practices and skills required to develop and implement an effective antimicrobial stewardship programme.

In animal health

- **Ban on antibiotic growth promoters, carbapenems and colistin in food-producing animals.** Singapore's farms have long ceased the practice of using antibiotics to accelerate the growth of animals. However, to ensure that antibiotic growth promoters not used in Singapore's farms, a directive was issued by the former AVA in November 2018 to explicitly prohibit the use of antibiotics for growth promotion in livestock and aquaculture. The antibiotics listed on the directive were then added to

the existing list of banned drugs which contains certain antibiotics which are critical to human health, such as carbapenams and colistin, which are deemed drugs of last resort when other antibiotics fail to work.

Moving ahead

- Engaging the private sector to promote antimicrobial stewardship programmes and practices;
- Several national guidelines are in the process of development, including
 - National guideline on the prudent use of antimicrobials in companion animals (*final draft*)
 - National surgical antibiotic prophylaxis consensus guidelines to guide and support the optimised use of prophylactic antibiotics and reduce inappropriate prescribing in surgical practices (*final draft*)
 - National guidelines to guide primary healthcare providers in the management of upper respiratory tract infections.
- Current regulations on the use of veterinary drugs are being reviewed and strengthened to establish a framework for veterinary drug registration and for veterinary prescription for drugs used in all animal sectors.

INTERNATIONAL AND REGIONAL COLLABORATIONS

The spread of drug-resistant organisms and resistance genes are facilitated by international movement of people, animals, food and other products. As an international travel hub⁷ and net importer of food⁸, Singapore is particularly susceptible to the introduction of emerging resistant organisms. Singapore is a member of ASEAN, which has recently developed a strategic framework to address AMR as a region. As a member of FAO, OIE, WHO and UNEP, Singapore also collaborates with these international organisations to combat AMR at a global level.

Regional collaborations

- **First FAO ATLASS Regional Assessor Training in Singapore, 7-10 May 2018.** The Assessment Tool for Laboratory and AMR Surveillance Systems (ATLASS) was developed by the FAO to assess and build capacity of countries for AMR surveillance in agriculture. To build a pool of trained assessors for the region, FAO, with the support of the United Kingdom's Fleming Fund and the United States Agency for International Development (USAID), conducted the first regional training from 7-10 May 2018 in Singapore, hosted by the former AVA. The training included participants from Singapore, Indonesia, Philippines, Republic of Korea, Thailand and Vietnam. As part of the training, an actual ATLASS mission was also conducted for Singapore, with the trainers serving as the lead assessors. More information may be found at www.fao.org/asiapacific/news/detail-vents/en/c/1129839/
- **Adoption of the ASEAN Plus Three Leaders' Statement on Cooperation Against Antimicrobial Resistance, 13 November 2018, Singapore.** The ASEAN Plus Three Leader's Statement on Cooperation Against AMR was adopted at the 21st ASEAN Plus Three (consisting of the People's Republic of China, Japan, and the Republic of Korea) Summit held on 15 November 2018 in Singapore. The Statement reaffirmed the ASEAN Plus Three leaders' commitments to address the growing threat of AMR, and to support countries in the formulation and implementation of National Action Plans against AMR through the One Health approach. The full statement can be found at

⁷ A record of 18 million visitor arrivals in 2018

⁸ Over 90% of Singapore's food is imported. In 2019, Singapore imported 206,415 tonnes of chicken, 116,562 tonnes of pork and 94,590 tonnes of fish. SFA Annual Report 2019-2020, www.sfa.gov.sg

<https://asean.org/asean-plus-three-leaders-statement-cooperation-antimicrobial-resistance-amr/>.

- **Development of the ASEAN Strategic Framework to Combat Antimicrobial Resistance.** Following the adoption of the ASEAN Leaders' Declaration (ALD) to combat AMR on the 31st ASEAN Summit in November 2017, Singapore and other ASEAN Member States participated in a workshop to develop a multi-sectoral regional framework to combat AMR in ASEAN, led by the Philippines. Singapore's delegation comprised of representatives from MOH, NCID, NParks and SFA, representing the health, animal and food sectors. The *ASEAN Strategic Plan to Combat AMR through a One Health Approach* was launched at the 14th ASEAN Health Ministers Meeting in Siem Reap, Cambodia, held from 26 to 31 August 2019, and endorsed by the Senior Officials Meeting for health (SOMHD), agriculture and forestry (SOM-AMAF), ASEAN Consultative Committee on Standards and Quality (ACCSQ) and ASEAN Cooperation on Environment (ASOEN). The full ASEAN Leader's Declaration can be found at <https://asean.org/asean-leaders-declaration-on-antimicrobial-resistance-amr-combating-amr-through-one-health-approach/>.
- **FAO's Regional Antimicrobial Resistance Monitoring and Surveillance Guidelines Volume 1: Monitoring and surveillance of antimicrobial resistance in bacteria from healthy food animals intended for consumption.** Singapore (SFA and NParks) contributed to the guidelines developed by FAO RAP in collaboration with Chulalongkorn University Veterinary Antimicrobial Resistance Cluster (CU VET AMR), in consultation with regional representatives and international experts. The publication of FAO's regional guidelines in 2019 will promote and facilitate regional harmonisation of AMR surveillance methods in food-producing animals in the region.
- **Singapore Antimicrobial Stewardship Training Course (SASTC).** Initiated in 2016, the SASTC is jointly organised by major public healthcare institutions in Singapore and aims to introduce best practices in antimicrobial therapy and the management of common infections, as well as the skills needed to establish antimicrobial stewardship programmes. The SASTC caters to a range of healthcare professionals from Singapore and the region, including doctors, pharmacists and nurses. A total of 50 participants attended the SASTC sessions held on 6 and 7 August 2018, with 72% from regional countries. In the following year, 57 participants attended the sessions on 20 and 21 August 2019, of whom 56% were overseas attendees. Due to the COVID-19 pandemic, the SASTC was not held in 2020.

International collaborations

- **WHO Joint External Evaluation (JEE) of Singapore’s capacity to manage public health threats, 16 – 20 April 2018.** The JEE is a voluntary process in which a country’s capacity to prevent, detect and rapidly respond to major public health threats is jointly assessed by a team of international and national experts. The JEE team agreed that “Singapore has demonstrated strong leadership and a highly developed capacity to detect and respond to potential public health emergencies”, while providing recommendations for further improvement. Specifically, the WHO evaluation team noted that Singapore’s One Health Framework is an effective mechanism for integrating surveillance and response to threats posed by zoonotic infections, AMR and food-borne illnesses. The full report can be found on the WHO website at <http://www.who.int/ihr/publications/WHO-WHE-REP-2018.25/en/>.
- **Singapore-United States Third Country Training Programme (SIN-US TCTP) regional training on AMR, 10-14 December 2018.** The Singapore-United States TCTP is a partnership between the Singapore Ministry of Foreign Affairs and the US, which provides technical assistance and capacity building to ASEAN Member States and Timor Leste. Experts from NCID, Nanyang Technological University (NTU), US Centers for Disease Control and Prevention (CDC), the US Geological Survey, NSW Department of Primary Industries and the World Bank shared on national policies to finance, monitor and evaluate progress in the implementation of national action plans to address the problem of AMR. Participants also visited NTU’s Food Technology Centre, where experts demonstrated the use of whole genome sequencing for surveillance of AMR in the food chain.
- **Water Environment and Research Foundation (WE&RF) (USA) project on “Occurrence, Proliferation, and Persistence of Antibiotics and Antibiotic Resistance during Wastewater Treatment”** (co-funded by PUB and other Global Water Research Coalition members)⁹

Moving ahead

- Development of monitoring and evaluation (M&E) indicators for the ASEAN Strategic Plan to Combat Antimicrobial Resistance. Following the launch of the ASEAN Strategic

⁹ Occurrence, Proliferation, and Persistence of Antibiotics and Antibiotic Resistance during Wastewater Treatment, The Water Research Foundation 2019, www.waterrf.org

Plan in August 2019, Thailand and Singapore will jointly develop the M&E framework that will be used to monitor the implementation of the ASEAN Strategic Plan by AMS;

- Singapore (SFA and NParks) is collaborating with FAO to jointly develop a series of Regional guidelines on “Monitoring and surveillance of AMR in aquaculture”, “Risk analysis of AMR arising from the use of antimicrobial agents in aquaculture”, and “Prudent use of antimicrobials in aquaculture”, in consultation with AMS and international experts. These will guide AMS in developing AMR surveillance and risk analysis programmes for the growing aquaculture industry in this region;
- Singapore (NParks) is collaborating with CLSI on developing antimicrobial susceptibility testing standards for tropical fish pathogens;
- Continued collaborative training efforts under the Singapore-United States TCTP to strengthen capabilities across ASEAN Member States and Timor Leste.

CHALLENGES

The challenges faced in achieving the aims of the NSAP are not unique to Singapore. Addressing them, however, requires contextualising it to Singapore's existing systems and regulatory frameworks, society, culture and priorities. Some of these challenges include:

- **Multiple stakeholders and sectors involved.** AMR issues cut across many sectors, including health, animals, agriculture, plants, environment, trade, education and industry. Likened to efforts to tackle climate change, turning the tide of rising AMR cannot be achieved by the work of one body or sector, but requires a concerted effort by all players and stakeholders in all sectors, ranging from policy-makers, corporations, industry, professionals and to individuals.
- **Relatively low awareness of AMR** of the general public in Singapore, as well as multi-lingual, multi-cultural considerations, poses unique challenges to public education. Education efforts will need to be targeted and sustained to raise awareness levels.
- **Social behaviour and economic factors.** Some of the challenges with controlling AMR are entrenched in social behaviour and economic factors. The socio-economic impacts of AMR in Singapore's context are currently not well understood. Research into these areas will provide us with a better understanding.
- **Limited data on antimicrobial utilisation in the community, veterinary clinics and agriculture.** Currently, the amount of antibiotics prescribed by general practitioners is not known, although they account for 80% of primary care visits. Likewise, information on utilisation by companion animals and in local agriculture is limited. One of the barriers in collecting such data are different systems used for recording antimicrobial usage, which may be electronic or manual. In the case of aquaculture, especially offshore farms, records are often incomplete. The AMR Coordinating Office will be exploring, in collaboration with key stakeholders, approaches to improve data collection in these sub-sectors.
- **Internet and over-the-counter overseas purchases** by local travellers. Antibiotics can be purchased easily on the internet without a prescription, and readily purchased in many countries over-the-counter where prescriptions are not required or enforced, although the extent of such practices are unknown. Public education on not taking antibiotics without a doctor's or veterinarian's prescription and international collaboration are needed to reduce such practices. In addition, there is currently a lack of a veterinary medicine registration system. Farmers are also able to purchase

antibiotics using only their farm licence. Regulations are currently being reviewed and strengthened to enhance regulatory control along the supply chain of antibiotics.

- **Influence of international movement and trade.** Singapore, as a net importing country, a global trade and tourist hub, is subject to multiple factors outside our control e.g. human immigration, international travel, medical tourism, trade, external environmental factors, all of which contribute to changing resistance trends and patterns of resistance. Continued collaboration and engagement at regional and international platforms remain important to mitigate risks and respond to emerging threats.
- **Long-term sustainability.** Finally, AMR is a perpetual problem that requires a long-term, sustained effort. Funding, resources and continued engagement will be needed to sustain national efforts as well as for effecting change in the region and beyond.

Impact of COVID-19 pandemic

The COVID-19 pandemic which started at the end of 2019 posed unique challenges to health systems as a whole. Resources across all sectors, hospitals and agencies were stretched during the pandemic in 2020, and this impacted on AMR control efforts. At the height of the outbreak from February to June 2020, antimicrobial stewardship activities in public hospitals were reduced to allow medical doctors and pharmacists to focus on related pandemic activities and on controlling the outbreak; these have since resumed from July 2020. Many AMR outreach programmes and regional activities had to be deferred or moved onto virtual platforms.

Despite these constraints, we did not face major impact on funding for AMR activities, on diagnostics and laboratory testing for AMR, or the availability of laboratory supplies and equipment for AMR activities. NARCC's continued monitoring did not reveal any significant increases to antimicrobial resistance rates. The pandemic also presented opportunities to increase awareness on hygiene, hand-washing, vaccination and other infection prevention measures, and on the impact of infectious diseases as a whole. The results of a global survey by WHO GLASS of 73 countries, including Singapore, on the impact of COVID-19 on AMR surveillance, prevention and control, is found at <https://www.medrxiv.org/conent/10.1101/2021.03.24.21253807v1>.

CONCLUSION

The development of a unified national action plan has led to strengthened collaboration on AMR across the human, animal, food and environment sectors in Singapore, resulting in joint efforts in public education, surveillance and research. Since the launch of the NSAP, a number of initiatives have been implemented to improve awareness, strengthen surveillance, improve IPC measures and antibiotic stewardship.

Educational initiatives and engagement events have been launched to reach out to professionals and farmers, to the public, and to school-age children. Key messages from current campaigns will be built upon in the coming years. AMR surveillance has been expanded to private hospitals and all terrestrial livestock farms. Joint reporting of surveillance activities forms the first step towards a more One Health approach to AMR and AMU surveillance and monitoring. As our surveillance systems develop and become more integrated, the information obtained will help identify areas of concern that need more targeted action and education.

However, continued efforts are important to reduce the development and spread of AMR, and reduce inappropriate antimicrobial use.

Efforts over the next few years will focus on increasing awareness of inappropriate antibiotic use, and on understanding factors that influence behaviour in various groups, including professionals, farmers and pet owners, such that educational efforts can be more targeted. Education will also include improving knowledge of infection prevention measures and promoting vaccination. We will continue to monitor the trends of priority antibiotic resistant bacteria in hospitals, animals and in the food chain, and improve the collection of data on antimicrobial usage in the community, in veterinary care and in farms. National guidelines on antibiotic use in primary care and on prudent use in animals will be developed to guide prescription and optimise use of antibiotics. Finally, we will continue to work with other ASEAN member states and international organisations on concerted action against the increasing threat of AMR in Southeast Asia.

While AMR cannot be eliminated, the threats it poses can be reduced and the risks mitigated. Continuing support and dedicated resources are essential, as are the participation and involvement of all stakeholders, if our ability to treat infectious diseases in humans and animals is to be preserved.

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¹⁰ This list may not be exhaustive. Publications listed here are based on the inclusion criteria for research involving Singapore and AMR, published within the time period 2009-2020. The search strategy included two rounds of database search in April 2019 and May 2020 with assistance from NTU library services, on Medline, Embase (Ovid), Global Health (EBSCO) and Cochrane Library. Results of the database search were extracted using Mendeley and Jabref for record-keeping purposes. Articles that did not meet the inclusion criteria, along with duplicated articles, were removed.

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