NATIONAL STRATEGIC ACTION PLAN ON AMR v2

Monitoring & Evaluation Framework (2025 – 2030)

Singapore

Working together to combat AMR

The NSAPv2 Monitoring and Evaluation Framework was developed by the One Health AMR Workgroup (OH AMRWG) and is jointly published by:

- Communicable Diseases Agency (CDA)
- National Environment Agency (NEA)
- National Parks Board (NParks)
- PUB, Singapore's National Water Agency (PUB)
- Singapore Food Agency (SFA)

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National Strategic Action Plan on Antimicrobial Resistance (version 2.0) - Monitoring & Evaluation Framework (2025 – 2030), Singapore

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ONE HEALTH AGENCIES:

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INTRODUCTION

Singapore's second National Strategic Action Plan on AMR (NSAPv2) envisions "*A Singapore where AMR is effectively controlled*", with the mission "**To prevent the emergence and spread of drug-resistant organisms, and preserve the effectiveness of antimicrobials in Singapore, through a One Health approach, protecting human, animal and environmental health in Singapore**".

This document sets out the first iteration of a framework for monitoring and evaluating (M&E) the NSAPv2. The M&E Framework is designed to measure effectiveness of the NSAP in fulfilling its mission and track progress of its implementation under the five Core Strategies. Taking the One Health perspective to reflect the multisectoral nature of AMR, targets and indicators were identified across human and animal health, food production, water and the environment sectors.

The NSAPv2 M&E framework comprises two parts:

I. The **Monitoring component (Part I)** encompasses two forms of monitoring:

a. Monitoring of the process and outputs - This focuses on the NSAP's inputs, activities and outputs, and is designed to monitor the progress of its implementation and to evaluate how to improve the efficiency of implementation.

b. Monitoring and evaluation of outcomes - This focuses on the NSAP's goals and targets, and is designed to assess the effectiveness of NSAP towards achieving its Mission through measurement of specific indicators.

Part I describes (i) the criteria for selection of targets and indicators, (ii) the targets and indicators selected for monitoring, (iii) how the activities of the Core Strategies will be tracked and (iv) how data will be collected and reported.

Technical Reference Sheets for Targets and Indicators are found in Annex A and Annex B respectively. Annex C describes the process involved in developing the NSAPv2 and M&E Framework.

II. The **Evaluation component (Part II)** describes how outcomes, impact and overall effectiveness of the NSAP will be assessed.

The intended audience for this framework includes the One Health AMR Workgroup (OH AMRWG; as the national multisectoral committee), the AMR Coordinating Office (AMRCO; as the national AMR secretariat), agencies in the respective sectors implementing AMR action and consultants advising national officials.

The NSAP M&E Framework will remain dynamic and be reviewed periodically to ensure relevance. As the global AMR situation evolves, so will Singapore's response. New knowledge on AMR and measures to contain it will continue to emerge. Singapore will also build on past experience and new evidence to advance our national strategy against AMR. More outcome-based targets will be set as the national strategy matures and baselines are established. The NSAP M&E Framework and indicators will be refined accordingly to reflect lessons learned and to incorporate new priorities for monitoring.

LOGIC MODEL

MISSION	INPUTS	INITIATIVES & ACTIVITIES	OUTPUTS & OUTCOMES		IMPACT
			Medium-term targets **By 2030**	Long-term targets	
To prevent the emergence and spread of drug-resistant organisms, and preserve the effectiveness of antimicrobials in Singapore, through a One Health approach protecting human, animal and environmental health in Singapore.	• Staff • National funding • Policies & Regulations • Laboratories • Technical capabilities • Research evidence • Partners	1. Communication & Education 2. Surveillance & Risk assessment 3. Research & Evidence 4. Prevention & Control of Infection 5. Optimisation & Stewardship	• Reliable estimates of deaths associated with AMR in sentinel healthcare settings are obtained and reported. • Antimicrobial stewardship programmes are implemented in all acute hospitals. • Antibiotic prescribing guidelines for at least seven common infections treated in primary care are developed and disseminated. • The quantity (kg) of sales of fluoroquinolones to farms is reduced. • A regulatory framework for antimicrobial use in the animal sector is established, including regulatory levers to ensure they are safe, effective, and only supplied through prescription. • Baseline levels of relevant antimicrobial resistant bacteria (ARBs) and antimicrobial resistance genes (ARGs) in sentinel environmental sites and water bodies are established. • Levels of relevant ARBs and ARGs in the sentinel environmental sites and water bodies are reported at least yearly. • Data from surveillance of priority drug-resistant organisms in the human, animal, food and environment sectors are integrated and correlated.	(to be determined)	• Reduced impact on health and well-being. • Reduced resistance and incidence of drug-resistant organisms. VISION: **A Singapore where AMR is effectively controlled.**

SECTION I: MONITORING THE NATIONAL STRATEGIC ACTION PLAN ON AMR

1. M&E Terminology

The following definitions apply in this Framework:

- **Goals**: Long-term objectives and the desired outcome or results of each Core Strategy.
- **Targets:** Specific, concrete and measurable benchmarks or outcomes that are to be achieved by a stated date or timeframe.
- **M&E Indicators:** Quantifiable metrics used to track progress of the NSAPv2 and assess its effectiveness. They include a combination of impact, output, outcome and process indicators to measure performance.

2. Goals

Table 1. NSAPv2 Goals

Overarching Goals	**1**. Reduced impact of AMR on health and well-being. **2**. Reduced resistance and incidence of drug-resistant organisms.
Core Strategy 1: **Communication and Education**	**3**. Improved awareness and behaviours concerning appropriate antimicrobial use and preventing the spread of drug-resistant infections. **4**. Evidence-based, up-to-date and practice-oriented professional education across sectors.
Core Strategy 2: **Surveillance and Risk Assessment**	**5**. A timely and comprehensive picture of AMR and AMU within and across sectors. **6**. Data from surveillance guides policy, practice and behaviour change approaches.
Core Strategy 3: **Research and Evidence**	**7**. Increased AMR research relevant to local policy and practices. **8**. Research evidence aids the formulation of national AMR strategies.
Core Strategy 4: **Prevention and Control of Infection**	**9**. Strengthened and effective infection prevention and biosecurity practices. **10**. Increased uptake of vaccination and alternatives to reduce reliance on antimicrobials. **11**. Contamination of our waters and environment by antimicrobials and AMR organisms and genes is minimised and mitigated.
Core Strategy 5: **Optimisation and Stewardship**	**12**. Sustained access to essential, safe and effective antimicrobials to treat infections. **13.** Evidence-based and prudent use of antimicrobials is supported by regulatory controls and professional oversight.

3. Targets

The NSAPv2 sets out eight targets to achieve by 2030, with the following criteria:

- **Specific**: Clear and specific on the desired outcome.
- **Measurable:** Measured by specific indicators.
- **Ambitious + Achievable**: Able to drive concrete action while avoiding low-hanging fruits.
- **Relevant**: The target must be relevant to the national context.
- **Timebound**: By 2030.
- **One Health**: Targets are distributed across all sectors.
- **Global alignment**: Supports the commitments of the 2024 UNGA HLM Political Declaration on AMR, where relevant.

Table 2 lists the targets to be achieved by 2030, mapped to the 13 goals of the NSAPv2 Core Strategies. Further descriptions of the targets are found in Annex A.

Table 2. NSAPv2 targets

	TARGET	RELATED GOALS
1	By 2030, reliable estimates of deaths associated with AMR in sentinel healthcare settings are obtained and reported.	Goals 1, 6
2	By 2030, antimicrobial stewardship programmes are implemented in all acute care hospitals.	Goals 2, 3, 13
3	By 2030, antibiotic prescribing guidelines for at least seven common infections treated in primary care are developed and disseminated.	Goals 2, 3, 4, 13
4	By 2030, the quantity (kg) of sales of fluoroquinolones to farms is reduced.	Goals 2, 3, 4, 5, 9, 10, 13
5	By 2030, a regulatory framework for antimicrobial use in the animal sector is established, including regulatory levers to ensure they are safe, effective and only supplied through prescription.	Goals 2, 4, 12, 13
6	By 2030, baseline levels of relevant antimicrobial resistant bacteria (ARBs) and antimicrobial resistance genes (ARGs) in sentinel environmental sites and water bodies are established.	Goals 2, 5, 8, 11
7	By 2030, levels of relevant ARBs and ARGs in the sentinel environmental sites and water bodies are reported at least yearly.	Goals 2, 5, 8, 11
8	By 2030, data from surveillance of priority drug-resistant organisms in the human, animal, food and environment sectors are integrated and correlated.	Goals 2, 5, 7, 11

4. M&E indicators

The NSAPv2 M&E Indicators measure progress towards the Mission and facilitate evaluation of whether strategies and related activities are effective in achieving the mission and goals of the NSAPv2. Table 2 lists the indicators for monitoring from 2025 to 2030, with full technical descriptions and definitions found in Annex B. Other M&E indicators may be developed as needed.

Indicators were selected based on the following criteria:

- **Specific**: The indicator can be clearly defined with no ambiguous terms.
- **Measurable:** The indicator must have identifiable sources of data, or the methods to collect the data can be established.
- **Relevant:** The indicator must be relevant to the Mission of the NSAP.
- **Comparable over time** (e.g. 3-5 years) to reliably measure trends.
- **Global alignment:** Aligned with the Global Action Plan M&E Framework[1] where relevant.
- Maximum of 25 indicators to ensure a manageable number for collection and reporting.

Table 3. List of M&E Indicators (2025 - 2030)

Type	Indicator
A. Impact Indicators	**A1**. Number of deaths in acute care hospitals associated with infection caused by drug-resistant organisms. **A2.** (i) Number of additional days of hospitalisation due to infection caused by drug-resistant organisms (DRO); (ii) Excess costs associated with DRO infection.
B. Output & Outcome indicators	Communication and Education **B1.** Proportion (%) of Singapore residents aged 18-74 years who know that inappropriate antibiotic use can lead to resistance. **B2.** Proportion (%) of Singapore residents aged 18-74 years who know that it is inappropriate to use antibiotics for viruses such as the flu or the common cold. **B3.** Proportion (%) of agriculture workers who know that misuse (or imprudent use) of antimicrobials can lead to AMR. Surveillance and Risk Assessment **B4.** Proportion (%) of bloodstream infections due to (i) Resistance of *E. coli* to 3rd generation cephalosporin; (ii) Resistance of *S. aureus* to methicillin (MRSA) in bloodstream infections. **B5.** Incidence of carbapenemase-producing Enterobacterales (CPE) in clinical samples from acute care hospitals. **B6.** Baseline prevalence of relevant ARBs and ARGs in sentinel environmental sites and water bodies.

[1] Monitoring and evaluation of the global action plan on antimicrobial resistance. www.who.int

	B7. (i) Prevalence and resistance of relevant ARBs; (ii) Prevalence of relevant ARGs in selected sites in the water and environment sector. **B8.** Occurrence of ESBL *E. coli* across the human, food, animal and environment sectors, as measured through One Health surveillance. **B9.** Occurrence and resistance of (i) *E. coli* (ii) *Salmonella* spp (iii) *Enterococci*, and other pathogens of One Health concern (to be defined) across relevant sectors, against a defined panel of antibiotics. Research and Evidence **B10**. Number of AMR research projects involving two or more sectors. Prevention and Control of Infection **B11.** Proportion (%) of target population vaccinated against (i) influenza and (ii) *Streptococcus pneumoniae.* Optimisation and Stewardship **B12**. Total national antimicrobial use or consumption in the human health sector, by type and class, measured in Daily defined dose (DDD) per 1000 inhabitants per day. **B13**. Proportion (%) of WHO Access antibiotics (i) for human use, relative to total antibiotic consumption (GAP Indicator 4.1b), and (ii) prescribed/used by polyclinics and GP clinics; in Defined Daily Doses. **B14**. Number of acute healthcare facilities implementing antimicrobial stewardship programmes. **B15**. Number of antibiotic prescribing guidelines for common infections treated in primary care developed and disseminated. **B16.** Number of antimicrobials approved for animal use that have undergone safety, efficacy, and quality evaluations. **B17.** (i) Antimicrobial sales for veterinary use, by type, class and sector, measured in kg; and (ii) Proportion of wholesalers reporting data. **B18.** (i) Percentage of total sales classified as WHO Highest Priority Critically Important Antimicrobial agents (HP-CIAs); and (ii) Quantity of sales of fluoroquinolone/quinolones to farms, in kg.

5. Data collection and reporting

Quantitative data on indicators will be collected by AMRCO on an annual basis and reported on the appropriate platform. This could include the One Health Report on AMR and AMU, the NSAP progress report, website, dashboard or other platforms designed for this purpose. Results and recommendations of the M&E will be reported to the One Health Coordinating Committee (OHCC).

6. Data management

AMRCO as Secretariat for the OH AMRWG serves as custodian of M&E data collected and will ensure that data and information are managed according to data governance requirements, until approved for public release.

SECTION II. EVALUATION

Evaluating the effectiveness of the NSAP involves assessing whether it achieves its goals and objectives, as well as helping us understand the impact of our strategies on stakeholders.

Evaluating the National Strategic Action Plan on AMR

Evaluation may be conducted via one or a combination of the following ways:

a. **Quantitative evaluation** *(Evaluating effectiveness)* - Quantitative data on defined set of indicators are collected and analysed for trending and benchmarking.

b. **Semi-quantitative evaluation** *(Evaluating efficiency of implementation)* - The proportion of activities in the Joint Workplan that are 'Completed', 'On Track', 'Delayed' or 'On hold/Stopped' per year.

c. **Qualitative evaluation** *(End-of-term evaluation)* – This could include (i) Descriptive updates on implementation of initiatives and activities; (ii) Feedback gathered from agencies, national committees and stakeholders through surveys, consultations, or interviews.

A full review and evaluation will be conducted by the OH AMRWG at least once every 5 years. This evaluation could take the form of an internal review, survey, third-party evaluation, research study or any combination of these, coordinated by the AMRCO of the Communicable Disease Agency (CDA).

In addition, the results of international assessments will also be taken into consideration:

- Tracking AMR Country Self-assessment Survey (TrACSS)
- WHO's International Health Regulations Joint External Evaluation (IHR JEE)
- FAO Assessment Tool for Laboratories and Surveillance Systems (ATLASS)

The collective findings of these evaluations and assessments should be documented in a comprehensive report that includes data analysis, key insights and recommendations for advancing Singapore's strategy to combat AMR. Evaluation results and recommendations will be reported by AMRCO to OH AMRWG and OHCC.

Review of M&E Framework

This Framework and the monitoring indicators should be reviewed at least every 5 years to ensure their relevance.

ANNEXES

Annex A: Target Reference Sheets

Annex B: Indicator Reference Sheets

Annex C: NSAPv2 and M&E Framework Development

ANNEX A. TARGET REFERENCE SHEETS

Target 1

By 2030, reliable estimates of deaths associated with AMR in sentinel healthcare settings are obtained and reported.

Indicator

- Number of deaths in acute care hospitals associated with infection caused by drug-resistant organisms. *[refer to Indicator Technical Sheet #A1]*

Rationale

Mortality represents a definitive, unambiguous and the most critical health outcome that can be measured, which allows for the assessment of the effectiveness of interventions in a standardised way. Mortality captures the net effect of an intervention on overall survival, encompassing both direct and indirect effects. The 2024 UNGA Political Declaration on AMR commits to reducing deaths associated with AMR by 10% globally by 2030. As AMR-associated deaths are currently not measured, this target aims to drive actions to initiate the measuring and monitoring of deaths associated with AMR in Singapore by 2030, to enable the setting of nationally relevant reduction targets as the next phase.

Current situation

The Institute of Health Metrics Evaluation (IHME) estimated that, in 2019, 10.7% of all deaths recorded in Singapore were associated with drug-resistant organisms (2300 of 21,446 total deaths); 2.34% of all deaths were attributed to drug-resistant organisms (502 of 21,446 total deaths) (1). However, local studies will be needed to be conducted to obtain verifiable and more reliable estimates of associated and/or attributable deaths.

Driving Action

This target is expected to drive the following actions:

- Development of standardised methodology to measure mortality associated/attributable to AMR.
- Studies to estimate the number of deaths associated and/or attributed to AMR in hospital settings.
- Secure the necessary resources to support such work.
- Develop policy communications and public education surrounding the impact of AMR on human health.
- Establish surveillance to routinely monitor and report trends in associated/attributable mortality.
- Generate local data to inform the setting of reduction targets, as appropriate.

References

1. Institute of Health Metrics Evaluation. The burden of antimicrobial resistance (AMR) in Singapore, 2019.

Target 2

By 2030, antimicrobial stewardship programmes are implemented in all acute care hospitals.

Indicator

- Number of acute hospitals implementing antimicrobial stewardship programmes (ASP). *[Refer to Indicator Technical Sheet #B14]*

Rationale

Antimicrobial stewardship programmes (ASP) were instituted in public hospitals in 2011 with positive outcomes: Many studies from various local institutions have reported that ASPs had improved the appropriateness of antibiotic prescriptions and reduced the duration of antibiotic use without compromising patient safety. Acceptance of ASP recommendations was associated with shorter lengths of stay, decreases in mortality and re-admissions, and substantial cost savings for patients (1 – 8). Ng et al (9) showed that a decrease in broad-spectrum antibiotic utilisation rate in five public institutions was followed by decrease in incidence density of antibiotic-resistant organisms.

Building on the first NSAP, this target aims to ensure that ASPs are implemented in all acute hospitals, including private hospitals and newly built public hospitals. This target will drive actions to support NSAPv2 Goal 13 '*Improved evidence-based and prudent use of antimicrobials in human health, animal health and food-production, supported by regulatory controls and professional oversight*', and the UNGA recommendation for 70% antimicrobial use to be of the 'Access' group of antimicrobials based on WHO's AWaRe classification.

Current Situation

Public acute hospitals are required to have in place antimicrobial stewardship programmes and report on specified ASP indicators to the MOH through the National AMR Control Committee. This is currently not a requirement for private hospitals, hence ASP activities in private sector are voluntary and largely ad-hoc. Challenges to implementation ASP include resource constraints, limited pool of professional expertise to support ASP (e.g. infectious disease specialists, pharmacists, microbiologists) as well as need for management support and recognition. Due to the different operating models, ASP conducted in public hospitals may not be fully transferrable to private hospitals.

Driving Action

This target is expected to drive the following actions:

- Collaborative work among public and private hospitals on improving antimicrobial stewardship.
- Strengthening professional expertise for ASP.
- Ensure more judicious and evidence-based use of antimicrobials, especially those in the Watch and Reserve categories of WHO's AWaRe list.

References

1. Liew YX, Lee W, Loh JC, et al (2012). Impact of an antimicrobial stewardship programme on patient safety in Singapore General Hospital. Int J Antimicrob Agents 40:55-60.

2. Loo LW, Liew YX, Lee W, Chlebicki P, Kwa AL (2015). Impact of antimicrobial stewardship program (ASP) on outcomes in patients with acute bacterial skin and skin structure infections (ABSSSIs) in an acute-tertiary care hospital. Infect Dis Ther 4(Suppl 1):15-25.

3. Cai Y, Shek PY, Teo I, et al (2016). A multidisciplinary antimicrobial stewardship programme safely decreases the duration of broad-spectrum antibiotic prescription in Singaporean adult renal patients. Int J Antimicrob Agents 47:91-6.

4. Teng CB, Ng TM, Tan MW, et al (2015). Safety and effectiveness of improving carbapenem use via prospective review and feedback in a multidisciplinary antimicrobial stewardship programme. Ann Acad Med Singapore 44:19-25.

5. Seah XF, Ong YL, Tan SW, et al (2014). Impact of an antimicrobial stewardship program on the use of carbapenems in a tertiary women's and children's hospital, Singapore. Pharmacotherapy 34:1141-50.

6. Ng TM, Phang VY, Young B, et al (2017). Clinical impact of non-antibiotic recommendations by a multi-disciplinary antimicrobial stewardship team. Int J Antimicrob Agents 50:166-70.

7. Lew KY, N g TM, Tan M, et al (2015). Safety and clinical outcomes of carbapenem de-escalation as part of an antimicrobial stewardship programme in an ESBL endemic setting. J Antimicrob Chemother 70:1219-25.

8. Liew YX, Lee W, Kwa AL, Chlebicki MP (2015). Cost effectiveness of an antimicrobial stewardship programme. Int J Antimicrob Agents 46:594-5.

9. Ng TM, et al (2023). Antibiotic utilisation and resistance over the first decade of nationally funded antimicrobial stewardship programmes in Singapore acute care hospitals. Antimicrobial Resistance & Infection Control 12:82. https://doi.org/10.1186/s13756-023-01289-x

Target 3

By 2030, antibiotic prescribing guidelines for at least 7 common primary care infectious disease conditions are developed and disseminated.

Indicators

- Number of antibiotic prescribing guidelines for common infections treated in primary care developed and disseminated. *[refer to Indicator Technical Sheet #B15]*

Rationale

More judicious use of antibiotics is needed in private sector primary care. Antibiotic use guidelines will help guide more appropriate prescribing for infections commonly treated in primary care.

This target will drive actions to support the NSAPv2 Goal 13 *'Improved evidence-based and prudent use of antimicrobials in human health, animal health and food-production, supported by regulatory controls and professional oversight'*, and the UNGA recommendation for at least 70% antimicrobial use to be from the 'Access' group of antimicrobials based on WHO's AWaRe classification.

Current situation

The primary care sector accounts for most of antibiotic use in Singapore (1). Private primary care clinics serve approximately 80% of the local population and uses a higher proportion of 'Watch' and 'Reserve' group antibiotics than polyclinics (2).

Driving Action

This target is expected to drive the following actions:

- Increased engagement with public and private sector primary care physicians on guideline development, antimicrobial stewardship and to understand the needs of the sector.
- Collaboration with primary care physicians on developing feasible models of ASP for the sector.
- Development of education tools and information aids to support doctor-patient communication and shared decision-making.
- Ensure more judicious and evidence-based use of antimicrobials, especially those in the Watch and Reserve categories of WHO's AWaRe list, which are more heavily used in the private sector.

References

1. One Health AMR Workgroup. One Health Report on Antimicrobial Utilisation and Resistance, 2021, Singapore.
2. AMR Coordinating Office, Communicable Disease Agency, unpublished data. Based on sentinel participating clinics.

Target 4

By 2030, the quantity (kg) of sales of fluoroquinolones to farms is reduced.

Indicator

- (i) Antimicrobial sales for veterinary use, by type/class and sector, measured in kg; and (ii) Proportion of wholesalers reporting data. *[refer to Indicator Technical Sheet #B17]*
- (i) Percentage of total sales classified as WHO Highest Priority Critically Important Antimicrobial agents (HP-CIAs); (ii) Quantity of sales of fluoroquinolones/quinolones to farms, in kg. *[refer to Indicator Technical Sheet #B18]*

Rationale

The antimicrobial classes categorised by WHO as HPCIAs are: Cephalosporins (3rd and 4th generation), quinolones (including fluroquinolones), polymyxins, phosphonic acid derivatives (1). It is crucial that the effectiveness of such antimicrobial agents be preserved, as loss of their efficacy due to the emergence of resistance would have a significant impact on human health, especially for people with life-threatening infections. Fluoroquinolone use in food animals is associated with infections by drug-resistant strains of *Campylobacter* in humans (2). Studies have shown a positive association between the use of quinolones in food animals and the prevalence of fluroquinolone resistance in *E. coli, K. pneumoniae, A. baumannii* and *P. aeruginosa* (3).

Current situation

Fluoroquinolones (enrofloxacin) is the main HPCIA used in food production in Singapore. At present, only wholesales data are available. Based on the 2021 sales data (4), 473 kg of fluoroquinolones were sold to the aquaculture sector, while there were no sales of cephalosporins (3rd and 4th generation), polymyxins (which are banned) or phosphonic acid derivatives. HPCIAs were not sold for terrestrial food-producing animal use. Third and fourth generation cephalosporins were used only for companion animals.

Driving Action

This target is expected to drive the following actions:

- Improving use of vaccination and good husbandry practices to reduce reliance on antimicrobials, especially HPCIAs
- Promoting uptake of veterinary professional services, such as the Aquatic Animal Health Services
- Promoting adherence to prudent use guidelines on the use of medically important antimicrobials
- Devising ways to collect data on fluroquinolone use on farms
- Improve the knowledge of agriculture workers on AMR and prudent antibiotic use
- Developing a roadmap for reducing fluoroquinolones sales/use in food production, in consultation with stakeholders.

References

1. WHO List of Medically Important Antimicrobials: A risk management tool for mitigating antimicrobial resistance due to non-human use, 2024.
2. Collignon P. (2005) Fluoroquinolone use in Food Animals, Emerg Infect Dis 11:1789 – 1192.

3. Kenyon C., et al (2021). Positive association between the use of quinolones in food animals and the prevalence of fluroquinolone resistance in E. coli, K. pneumoniae, A. baumannii and P. aeruginosa: A Global Ecological Analysis. Antibiotics (Basel) 10:1193.
4. One Health Antimicrobial Resistance Workgroup (2023). One Health Report on Antimicrobial Utilisation and Resistance, 2021. Singapore.

Target 5

By 2030, a regulatory framework for antimicrobial use in the animal sector is established, including regulatory levers to ensure they are safe, effective and only supplied through prescription.

Indicator

- B16. Number of antimicrobial products approved for animal use that have undergone safety, efficacy, and quality evaluations. *[refer to Indicator Technical Sheet #B16]*

Rationale

A sound regulatory framework ensures responsible supply and use of antimicrobials along the entire supply chain covering import, manufacture, distribution and sale. A regulatory framework for Veterinary Health Products (VHP) provides oversight on the quality, safety and efficacy for the import, supply and use of these products the animal sector. This will involve the registration of currently unregulated health products and licensing of companies to maintain market traceability. Key aspects of the framework include veterinary drug registration, licensing and inspection of dealers, pharmacovigilance, and maintaining regulatory levers to prevent unlawful diversion of medication and unauthorised supply locally.

Current situation

Currently, farmers are allowed to purchase and administer antimicrobials to their animals without a veterinary prescription (1). Work is ongoing to strengthen legislation and develop the governance framework for regulating VHPs.

Driving Action

This target is expected to drive the following actions:

- Establishment of mechanisms or structures to assess and register veterinary drugs to ensure their quality, safety and efficacy.
- Requirement of prescription for antimicrobial purchase and use.

References

1. National Strategic Action Plan on AMR, 2017, Singapore.

Targets 6 & 7

By 2030, baseline levels of relevant antimicrobial resistant bacteria (ARBs) and antimicrobial resistance genes (ARGs) in sentinel environmental sites and water bodies are established.

By 2030, levels of relevant ARBs and ARGs in the sentinel environmental sites and water bodies are reported at least yearly.

Indicators

- Baseline prevalence of relevant ARBs and ARGs in sentinel environmental sites and water bodies *[refer to Indicator Technical Sheet #B6]*
- Prevalence and resistance of relevant ARBs; (ii) Prevalence of relevant ARGs in sentinel sites in the water and environment sector. *[refer to Indicator Technical Sheet #B7]*

Rationale

The water and the environment sectors are vital for addressing the challenges of AMR, as they serve as key pathways for the transmission of AMR and the acquisition of novel antimicrobial resistance genes (ARGs) by bacteria. Environmental antimicrobial resistant bacteria (ARB) and ARGs emerge primarily due to human activities, particularly through the misuse and overuse of antibiotics in healthcare and agriculture. Globally, this has exacerbated the spread of ARBs, ARGs and mobile genetic elements (MGEs) in various water bodies and environments (both built and natural). This is a concern as there is a risk of these ARGs and MGEs being transferred to pathogenic bacteria. Routine monitoring of AMR in the environment serves several purposes: Firstly, it enables the evaluation of the impact of various human activities and the effectiveness of control measures. Secondly, it provides evidence-based guidance for risk assessment and policy development aimed at managing and reducing the environmental dissemination of ARBs and ARGs. Thirdly, it ensures compliance to measures and regulations aimed at minimising the discharge of antimicrobials into the environment.

Current situation

Research on AMR in the environmental dimension remains scarce. Pilot studies are on-going to investigate the presence of ARBs and ARGs in water and the environment (1,4). For instance, the investigations conducted by Pek et al (2) and Zhong et al (3) were the first to examine the occurrence of ARGs in recreational water in 2023 and Jurong Lake in 2021, respectively. Both studies highlighted the lack of information on ARGs in water sources in Singapore. In addition, Pek et al. (2) emphasised the significance of routinely collecting water samples, as seasonal variability may affect microbial composition. This underscores the necessity of systematic sample collection to comprehend the prevalence of AMR genes detected in environmental samples.

Driving Action

These targets are expected to drive the following actions:

- Expanding AMR surveillance to water and environmental sites that are not yet covered,
- Identification of relevant targets for surveillance in Singapore's context.
- Development of appropriate risk assessment methodologies for AMR in the environment.
- Establishment of routine environmental surveillance for ARBs and ARGs, contributing to integrated AMR surveillance.

References

1. One Health Antimicrobial Resistance Workgroup (2023). One Health Report on Antimicrobial Utilisation and Resistance, 2021. Singapore.
2. Pek, H. B., Kadir, S. A., Arivalan, S., Osman, S., Mohamed, R., Ng, L. C., Wong, J. C., & Octavia, S. (2023). Screening for extended-spectrum beta-lactamase *Escherichia coli* in recreational beach waters in Singapore. Future Microbiology, 18, 867–873. https://doi.org/10.2217/fmb-2023-0040
3. Zhong, Y., Guo, S., Seow, K. L. G., Ming, G. O. H., & Schlundt, J. (2021). Characterization of Extended-Spectrum Beta-Lactamase-Producing *Escherichia coli* Isolates from Jurong Lake, Singapore with Whole-Genome-Sequencing. International Journal of Environmental Research and Public Health/International Journal of Environmental Research and Public Health, 18(3), 937. https://doi.org/10.3390/ijerph18030937Zhong et al
4. Ng, C., Tay, M., Tan, B., Le, T.-H., Haller, L., Chen, H., Koh, T. H., Barkham, T. M. S., Thompson, J. R. and Gin, K. Y.-H. (2017). Characterization of Metagenomes in Urban Aquatic Compartments Reveals High Prevalence of Clinically Relevant Antibiotic Resistance Genes in Wastewaters. Frontiers in Microbiology, 8, Article 2200, 1-12.

Target 8

By 2030, data from surveillance of priority drug-resistant organisms in the human, animal, food and environment sectors are integrated and correlated.

Indicators

- Occurrence of ESBL *E. coli* across the human, food, animal and environment sectors, as measured through One Health surveillance. *[Refer to Indicator Technical Sheet #B8]*
- Occurrence and resistance of (i) *E. coli* (ii) *Salmonella* spp (iii*) Enterococci,* and other pathogens of One Health concern across relevant sectors, against a defined panel of antibiotics. *[Refer to Indicator Technical Sheet #B9]*

Rationale

A comprehensive surveillance system for AMR across One Health Sectors is essential to guide the development of effective evidence-based policy, antimicrobial stewardship and AMR control measures that consider the complex interconnections among humans, animals, food and the environment. The integration of data across sectors will also enable joint risk assessment from the One Health perspective.

Current situation

Systematic surveillance of AMR and antimicrobial utilisation is being implemented in a stepwise approach across sectors (1). Routine national surveillance programmes have been established in the human, animal and food sectors since the 2010s, while surveillance in the environment sector was implemented more recently and conducted as scientific studies. The first six years of NSAP implementation have laid important pillars that are foundational to achieving an integrated surveillance system: (i) strengthened sector-specific surveillance and laboratory capacity for AMR in all sectors; (ii) the availability of regional surveillance guidelines; (iii) improved transparency and information sharing through joint reporting; and (iv) increased cross-sector research collaborations to study AMR transmission pathways in Singapore. These developments collectively set the momentum towards an integrated AMR surveillance system that can advance our understanding of AMR transmission in Singapore.

Driving Action

This target is expected to drive the following actions:

- Routine AMR surveillance in all relevant sectors
- Identification of nationally relevant One Health surveillance targets
- Development of a national governance framework and harmonised methodologies for One Health AMR surveillance
- Development of a central One Health database.
- Joint risk assessments of AMR.

References

1. One Health Antimicrobial Resistance Workgroup (2023). One Health Report on Antimicrobial Utilisation and Resistance, 2021. Singapore.

ANNEX B. INDICATOR REFERENCE SHEETS

1. Indicator A1: Mortality due to AMR

Indicator name	Number of deaths in acute care hospitals (i) associated with and (ii) attributed to infection caused by drug-resistant organisms (DRO).
NSAP Goal 1	Reduced impact of AMR on health and well-being.
Rationale for monitoring	This indicator serves to monitor the impact of AMR and progress towards implementing mechanisms to measure deaths associated and attributed to AMR. Mortality represents a definitive, unambiguous and the most critical health outcome that can be measured, which allows for the assessment of the effectiveness of interventions in a standardised way. Mortality captures the net effect of an intervention on overall survival, encompassing both direct and indirect effects.
Definition(s)	• '*Acute care hospitals'* are defined as hospitals that provide healthcare services to an inpatient to treat a brief but severe episode of illness or any disease or trauma, or during recovery from surgery (hcsa.hov.sg); any hospital licensed and classified by the Ministry of Health Singapore as an acute care hospital. • '*Attributable death or mortality'* is defined as the excess mortality among patients with AMR BSI when compared to patients without such an infection, adjusted for the influence of confounding factors. • '*Associated death or mortality'* is defined as deaths that occur from a drug-resistant infection, but the resistance may or may not have been the direct cause. • *'Infection caused by drug-resistant organisms'*: Bloodstream infections caused by (i) MRSA, (ii) ESBL *E. coli* (1) and (iii) other pathogens according to national priorities.
Data sources (existing or potential)	This indicator is currently not being monitored. Data will be collected through research or commissioned study.
Method of measurement	Data will be collected through research or commissioned study.
Method of estimation	To be determined
Agency responsible	CDA
Baseline	To be determined by local studies.
Target	By 2030, reliable estimates of deaths associated with AMR in sentinel healthcare settings are obtained and reported.
International alignment	This is aligned with the UNGA 2024 Political Declaration commitment to reduce the global deaths caused by bacterial antimicrobial resistance by 10% by 2030 against the baseline of 2019.
Data limitations	Associated mortality measures patients that died *with* an AMR infection, not whether the patient died *because* of the infection. It does not consider the possibility of a patient dying

	by the same infection caused by a susceptible strain of the same bacteria. Hence associated mortality may overestimate the excess of mortality associated with AMR (1).
Frequency of reporting	To be determined
References	1. GLASS Method for estimating attributable mortality of antimicrobial bloodstream infections, WHO 2021 2. 2024 UNGA Political Declaration on AMR

2. Indicator A2: Excess hospitalisation days and cost

Indicator name	(i) Number of additional days of hospitalisation due to infection caused by drug-resistant organisms (DRO). (ii) Excess costs associated with DRO infection
NSAP Goal 2	Reduced impact of AMR on health and well-being.
Rationale for monitoring	This indicator serves to monitor the impact and economic burden of AMR. Estimating the financial impact of DROs provides information on the economic burden of AMR and guide decision-making regarding funding of infection control measures, antimicrobial stewardship programmes, and other interventions.
Definition(s)	• '*Days of hospitalisation'* is the duration of a single episode of hospitalisation, calculated by subtracting date of admission from date of discharge. • '*Infection caused DRO'* refers to infections caused by a drug-resistant bacterial species of national priority (to be identified) • '*Excess costs'* is the additional cost of treating patients with infections that are resistant to drugs compared to treating patients with non-resistant infections.
Data sources (existing or potential)	This indicator is currently not routinely monitored.
Method of measurement	Data will be collected through research or commissioned study.
Method of estimation	To be determined.
Agency responsible	CDA
Baseline	Not available. Studies in selected hospitals estimated that the mean cost of a single healthcare-associated infection was approximately $1,809, translating to an annual lost bed days of about 56,000 days and an economic burden of $152 million (1). Methicillin-resistant *Staphylococcus aureus* (MRSA) infections in Singapore increased the length of stay by nearly four days compared with patients who did not have MRSA; each MRSA infection resulted in an excess cost of $3,200 (2). This translated to over $500,000 per 100,000 admissions.
Target(s)	-
International alignment	-
Data limitations	Subject to availability and completeness of healthcare financial data, which are collated from various sources e.g. billing data, prescription. May not demonstrate costs from patient's perspective, as such data are less readily available.
Frequency of reporting	To be determined.
References	1. *Estimatating the excess bed days and economic burden of health-care associated infections in Singapore public acute-care hospitals.* Cai Y, Venkatachalam I, Kwa A,

Tambyah P, Hsu LY, Marimuthu K and Graves N. 9, s.l. : Infection Control & Hospital Epidemiology, 2021, Vol. 43.

2. *The attributable mortality, length of stay and healthcare costs of methicillin-resistant Staphylococcus aurues infections in Singapore.* Cai Y, Philip EC, Arora S, Sim J XY, Cow W, Nazeha N et al. 100427, s.l. : IJID Regions, 2024, Vol. 12.

3. Indicator B1: Awareness of AMR

Indicator name	Proportion (%) of Singapore residents aged 18-74 years who know that inappropriate antibiotic use can lead to resistance
Goal	Improved awareness and behaviours concerning appropriate antimicrobial use and preventing the spread of infections.
Rationale for monitoring	This indicator measures the level of awareness among the general public of AMR as a consequence of inappropriate antibiotic use. The data may also reveal if misconceptions on antibiotic use requires educational interventions.
Definition(s)	• '*Singapore residents'* are defined as Singaporean residing (citizens and PRs) in Singapore. • '*Proportion who know'* refers to the percentage (%) of survey participants who respond 'yes' to the relevant statement(s) in the National Population Health Survey (NPHS) • ''Inappropriate antibiotic use' refers to any one or more of a list of practices as given in the NPHS. • '*Resistance"* here refers to antibiotic resistance, i.e. the loss of effectiveness of the antibiotic to treat the infection caused by the bacteria.
Data sources (existing or potential)	• National Population Health Survey • KAP research study
Method of measurement	NPHS methodology
Method of estimation	[Number of respondents who answered 'Yes' to the relevant statement(s) in the NPHS / Total number of residents surveyed] x 100%. With the statement(s) in English being, "Antibiotics will lose its effectiveness in the long term if one takes antibiotics for common cold and flu, does not complete the full course of antibiotics or take leftover antibiotics." or other similarly worded statements designed to measure this indicator.
Agency responsible	CDA
Baseline	Based on the Singapore National Population Health Survey in 2023, 87.1% agreed that misuse of antibiotics can result in antibiotics losing its effectiveness in the long run. [1]
Target(s)	NA
International Alignment	This indicator is in line with the Global Action Plan Indicator proposed additional standard AMR progress indicator 'Percentage of public who know use of antibiotics contributes to resistance'.[2]
Data limitations	Responses given may not reflect actual behaviour.
Frequency of reporting	Annual
References	1. National Population Health Survey, 2023

2. WHO, FAO and OIE, 2019. Monitoring and evaluation of the global action plan on antimicrobial resistance: framework and recommended indicators.

4. Indicator B2: Awareness that antibiotics are inappropriate for viruses

Indicator name	Proportion (%) of Singapore residents aged 18-74 years who know that it is inappropriate to use antibiotics for viruses such as flu or the common cold.
NSAP Goal	Improved awareness and behaviours concerning appropriate antimicrobial use and preventing the spread of infections.
Rationale for monitoring	This indicator monitors the awareness of the general public on the inappropriateness of using antibiotics for viruses. Understanding the public's awareness would allow for more targeted educational interventions when necessary, so as to promote appropriate antibiotic use.
Definition(s)	• '*Singapore residents'* are defined as Singaporean residing (citizens and PRs) in Singapore. • '*Proportion who know'* refers to the percentage (%) of survey participants who respond 'yes' to the relevant statement(s) in the National Population Health Survey (NPHS) • ''Inappropriate to use' here refers to being unsuitable or incorrect to prescribe or treat with antibiotics. • '*Flu'* refers to infections caused by influenza viruses.
Data sources (existing or potential)	• National Population Health Survey • KAP research study
Method of measurement	NPHS methodology
Method of estimation	[Number of respondents who answered 'Yes' to the relevant statement(s) in the NPHS / Total number of residents surveyed] x 100%. With the statement in English being, '*It is not appropriate to use antibiotics for viruses such as the flu.'* or other similarly worded statements designed to measure this indicator.
Agency responsible for data collection	CDA
Baseline	Based on the [1]Singapore National Population Health Survey 2023, 49% of respondents know that antibiotics do not work on the flu virus.
Target(s)	NA
International alignment	This indicator is in line with WHO's proposed additional standard AMR progress indicator* 'Percentage of public who know it is inappropriate to use antibiotics for a common cold or viruses'.[2]
Data limitations	Responses given may not reflect actual behaviour.
Frequency of reporting	Annual
References	1. National Population Health Survey, 2023 2. WHO, FAO and OIE, 2019. Monitoring and evaluation of the global action plan on antimicrobial resistance: framework and recommended indicators.

5. Indicator B3: Awareness of farmers

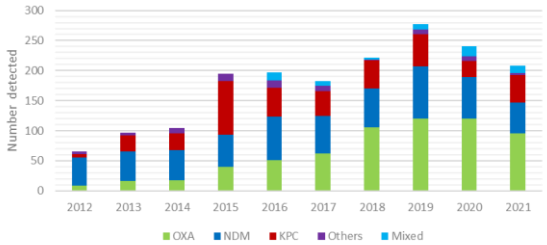
Indicator name and number	Proportion (%) of agriculture workers who know that misuse (imprudent use) of antimicrobials will lead to AMR.
NSAP Goal	Improved awareness and behaviours concerning appropriate antimicrobial use and preventing the spread of infections.
Rationale for collection	Antimicrobial use in the food and animal sector impacts the prevalence of AMR. [1]Poor biosecurity compliance is often related to a lack of knowledge or comprehension. Hence, greater awareness of the implications of the misuse of antimicrobials would increase the likelihood of adherence to the evidence-based guidelines on prudent use of antimicrobials. In that respect, the collection of this data can help identify any knowledge gaps where education efforts can be targeted.
Definition(s)	• 'Agriculture workers' refer to persons who own, oversee, manage, maintain, tend to or are otherwise involved in food production on local farms, both terrestrial and aquaculture.
Data sources (existing or potential)	SFA
Method of measurement	Survey or qualitative questionnaire
Method of estimation	(Number of agriculture workers who know that misuse of antimicrobials will lead to AMR / Total number of agriculture workers sampled) x 100%
Agency responsible for data collection	SFA
Baseline	No national baseline at present. [1]Based on a qualitative study conducted in Singapore between 2017 to 2018, participants remarked that there was low awareness of AMR both as a topic as well a term among One Health stakeholders, including farmers and others within the environmental health sector.
Target	Increasing trend over time.
Alignment with global target	NA
Data limitations	Results collected from the sample may not be representative of the whole population. Awareness of misconceptions does not necessarily reflect the desired behaviour of refraining from misusing antimicrobials. Follow-up questions would be needed to assess desired behaviour.
Frequency of reporting	To be determined
References	[1]Singh, S. R., Chua, A. Q., Tan, S. T., Tam, C. C., Hsu, L. Y., & Legido-Quigley, H. (2019). Combating Antimicrobial Resistance in Singapore: A Qualitative Study Exploring the Policy Context, Challenges, Facilitators, and Proposed Strategies. *Antibiotics (Basel, Switzerland)*, *8*(4), 201. https://doi.org/10.3390/antibiotics8040201

6. Indicator B4: SDG Indicators

Indicator name	[SDG Indicator] Proportion (%) of bloodstream infections due to selected AMR: (i) Resistance of *E. coli* to 3rd-generation cephalosporin (ii) Resistance of *S. aureus* to methicillin (MRSA) in bloodstream infections
NSAP Goal 2	Reduced resistance and incidence of drug-resistant organisms.
Rationale for collection	This indicator will measure the percentage (%) of bloodstream infections due to selected AMR: (i) Resistance of *E. coli* to 3rd-generation cephalosporin (ii) Resistance of *S. aureus* to methicillin (MRSA) in bloodstream infections. Collection of these indicators enable the reporting of Sustainable Development Goal (SDG) indicator 3.d.2 for global monitoring. **Rationale as SDG Indicators**: *E. coli* and *S. aureus* are among the most common human fast-growing bacteria causing acute human infections. *E. coli* is highly frequent in both humans, animals and the environment, being an excellent indicator for monitoring AMR across the sectors in line with the One Health approach. MRSA and *E. coli* resistant to 3rd-generation cephalosporin are largely disseminated and often in high frequency in hospital settings all over the world. Infections with these types of AMR lead to increase in use of the last resort drugs (e.g., vancomycin for MRSA infections, and carbapenems for ESBL- *E. coli*) against which new types of AMR are emerging. Effective control of these two types of AMR will ultimately preserve the capacity to treat infections with available antimicrobials while new prevention and treatment solutions can be developed. Bloodstream infections of hospital origin due to MRSA can also monitor the effectiveness of infection prevention measures in healthcare facilities (1).
Definition(s)	• Proportion of bloodstream infections due to MRSA and *E. coli* resistant to 3rd-generation cephalosporin (e.g., ESBL- *E. coli*) among patients seeking care and whose blood sample is taken and tested. • '*E. coli* resistant to 3rd-generation cephalosporins': *E. coli* isolates that are defined as resistant according to internationally-recognised clinical breakpoints for third generation cephalosporins (e.g., EUCAST or CLSI), specifically ceftriaxone or cefotaxime or ceftazidime (1). • Presumptive MRSA isolates as defined by oxacillin minimum inhibitory concentration (MIC) and cefoxitin disc diffusion tests according to internationally recognised clinical breakpoints (e.g., EUCAST or CLSI). (1)
Data sources (existing or potential)	• GLASS (2) • Sustainable Development Goals, www.singstat.gov.sg
Method of measurement	Cases of AMR infection found among patients from whom routine clinical samples have been collected for blood culture at surveillance sites (health care facility) according to local clinical practices, and antimicrobial susceptibility tests (AST) performed for the isolated blood pathogens as per international standards. The microbiological results (bacteria identification and AST) are de-duplicated and combined with patient data related to population data from the surveillance sites. Data are collated and validated at national level and reported to GLASS where epidemiological statistics and metrics are generated. GLASS has published guidelines on the set up of national AMR surveillance systems and the GLASS methodology implementation manual is available to countries. Although national representativeness of generated AMR rates is not a strict requirement, GLASS encourages countries to derive representative national data. (1)
Method of estimation	Proportion of patients with bloodstream infections due to selected antimicrobial resistant organisms. This is derived from the following and multiplied by 100 (1): Numerator: Number of patients with growth of methicillin-resistant S. aureus or E. coli resistant to third generation cephalosporins in tested blood samples. Denominator: Total number of patients with growth of S. aureus or E. coli in tested blood samples.

Agency responsible	CDA
Baseline	In 2023, the proportion of bloodstream *E. coli* resistant to 3rd generation cephalosporin was 24.4%; the proportion of bloodstream MRSA was 23.6%.
Target(s)	NA
International alignment	SDG Indicator 3.d.2: Proportion of bloodstream infections due to selected antimicrobial-resistant organisms, median (%). GAP Core Outcome Indicator II. Patterns and trends in resistance in human health: Prevalence of bloodstream infections caused by the following: a: Methicillin-resistant Staphylococcus aureus; b: ESBL in *E. coli* – third-generation cephalosporin resistance as a proxy. [3]
Data limitations	May be affected by the number and size of sentinel hospitals participating in the surveillance form year to year.
Frequency of reporting	Annual
References	1. UN Sustainable Development Goals. https://www.who.int/data/gho/data/indicators/indicator-details/GHO/sdg-3.d.2--proportion-of-bloodstream-infections-due-to-selected-antimicrobial-resistant-organisms--median-(-) 2. World Health Organization. Global Antimicrobial Resistance Surveillance System (GLASS) websites: http://www.who.int/glass/en/ 3. Global Action Plan Monitoring and Evaluation, 2019

7. Indicator B5: Carbapenemase-producing Enterobacterales

Indicator name	Number and Incidence of carbapenemase-producing Enterobacterales (CPE) in clinical samples from acute care hospitals.
NSAP Goal 2	Reduced resistance and incidence of drug-resistant organisms.
Rationale for collection	This indicator serves to monitor trends in CPE and measure the impact of enhanced measures to control CPE in acute healthcare facilities.
Definition(s)	• '*Carbapenemase-producing Enterobacterales'* refer to Enterobacterales tested positive for carbapenemase production or carbapenemase genes. • '*Incidence*' or incidence density refers to the number of new cases of the target pathogen detected over the six-month collection period in the inpatient population, expressed as per 10,000 inpatient days. Includes hospital and community onset cases. • '*Clinical samples'* refer to all specimens obtained as part of clinical management to diagnose infections, including blood. • '*Acute care hospitals'* are defined as hospitals that provide healthcare services to an inpatient to treat a brief but severe episode of illness or any disease or trauma, or during recovery from surgery (hcsa.hov.sg); any hospital licensed and classified by the Ministry of Health Singapore as an acute care hospital. Includes all public and private hospitals reporting data to NARCC.
Data sources (existing or potential)	National Antimicrobial Resistance Control Committee (NARCC)
Method of measurement	As reported by hospital microbiology laboratories. Duplicates within the NARCC six-month reporting period are excluded. Data are disaggregated by public and private hospitals.
Method of estimation	$\frac{Total\ No.of\ cases\ detected\ over\ the\ 6-month\ period^{*}}{\sum Hospital\ inpatient\ days\ for\ the\ same\ period} \times 10{,}000$
Agency responsible for data collection	CDA
Baseline	Refer to One Health Report on AMR and AMU, 2021[2]. Carbapenemases detected in clinical isolates from all acute care hospitals, 2012 – 2021. 
Target	NA
International alignment	GAP Indicator (Annex 2): Prevalence of bloodstream infections caused by (a) Carbapenem resistance in Enterobacteriaceae – *E. coli, Klebsiella.*[1]
Data limitations	The use of inpatient days as a denominator allows for a measurement of the incidence density (cases per 10,000 inpatient days) to be obtained and for normalisation across

	hospitals of different sizes. Antimicrobial resistance data are obtained from microbiology laboratories which may include data derived from samples submitted by outpatient facilities.
Frequency of reporting	Six-monthly
References	1. WHO, FAO and OIE, 2019. Monitoring and evaluation of the global action plan on antimicrobial resistance: framework and recommended indicators. 2. One Health AMR Workgroup, 2023. One Health Report on Antimicrobial Resistance and Utilisation in Singapore, 2019.

8. Indicator B6: Baseline prevalence in water and environmental sites.

Indicator name and number	Baseline prevalence of relevant ARBs and ARGs in sentinel environmental sites and water bodies.
NSAP Goals 5 & 11	Timely and comprehensive picture of AMR and AMU within and across sectors. Contamination of waters and environment by antimicrobials and AMR organisms and genes is minimised and mitigated.
Rationale for collection	This indicator measures progress in expanding the coverage of surveillance in the water and environment sector. This facilitates risk assessment and establishes baselines for monitoring patterns and changes in ARBs and ARGs reservoirs in the environment. Additionally, it will contribute to a better understanding of the dynamics and prevalence of AMR in water and environment.
Definition(s)	• *Water*' refers to various types of water bodies and sources that are part of the environment, such as surface water, wastewater, marine and coastal waters. • '*Sentinel environment sites and water bodies'* refer to sites identified for surveillance by NEA and PUB. This may include locations or facilities that are crucial for water management, distribution and treatment; and public-exposed aquatic environments, including freshwater bodies, marine waters and beaches. • '*Relevant Antibiotic-resistant bacteria (ARBs)'*: These may include ESBL *E. coli* and vancomycin-resistant Enterococcus, and others as determined, subject to their prevalence in environmental samples and their association with clinically significant antibiotic resistance. • "*Relevant Antimicrobial Resistance Genes (ARGs*)": These may include beta-lactam resistance genes, tetracycline resistance genes, quinolone resistance genes, sulfonamide resistance genes and macrolide resistance genes, and others as determined, subject to their prevalence in environmental samples and their association with clinically significant antibiotic resistance.
Data sources (existing or potential)	NEA, PUB
Method of measurement	Collection, analysis and compilation of ARB and/or ARG data from relevant water and environment sites.
Method of estimation	NA
Agency responsible for data collection	NEA, PUB
Baseline	To be determined.
Target	By 2030, baseline levels of relevant antimicrobial resistant bacteria (ARBs) and antimicrobial resistance genes (ARGs) in sentinel environment sites and water bodies are established.
International alignment	Supports the commitment of the 2024 UNGA Political Declaration Para 78, to: 'Address research gaps and promote knowledge generation on the environmental aspects of antimicrobial resistance, including identifying appropriate methods for environmental surveillance, to inform the integration of environmental aspects in the development and

	implementation of national action plans on antimicrobial resistance as well as priority-setting and policymaking on antimicrobial resistance.’
Data limitations	-
Frequency of reporting	-
References	-

9. Indicator B7: ARBs and ARGs in water/environment

Indicator name	Levels of relevant ARBs and ARGs within sentinel environmental sites and water bodies.
NSAP Goals 5 & 11	Timely and comprehensive picture of AMR and AMU within and across sectors. Contamination of waters and environment by antimicrobials and AMR organisms and genes is minimised and mitigated.
Rationale for collection	Regular monitoring is crucial for promptly identifying any changes and establishing an early warning system for potential public health hazards, thereby ensuring the protection of public health and safety, and that the environment is safe for public use.
Definition(s)	• '*Water*' refers to various types of water bodies and sources that are part of the environment, such as surface water, wastewater, marine and coastal waters. • '*Sentinel environmental sites and water bodies* refer to sites identified for surveillance by NEA and PUB. This may include locations or facilities that are crucial for water management, distribution and treatment; and public-exposed aquatic environments, including freshwater bodies, marine waters and beaches. • '*Relevant Antibiotic-resistant bacteria (ARBs)'*: These may include ESBL *E. coli,* carbapenemase-producing *E. coli,* vancomycin-resistant *Enterococcus*, and others as determined, subject to their prevalence in environmental samples and their association with clinically significant antibiotic resistance. • '*Relevant Antimicrobial Resistance Genes (ARGs*)': These may include beta-lactam resistance genes, tetracycline resistance genes, quinolone resistance genes, sulfonamide resistance genes and macrolide resistance genes, and others as determined, subject to their prevalence in environmental samples and their association with clinically significant antibiotic resistance.
Data sources (existing or potential)	NEA, PUB
Method of measurement	Collection and testing of environmental samples from pre-determined sites by microbiology culture followed by antibiotic susceptibility testing for ARBs, and by molecular/genomic methods for ARGs.
Method of estimation [formula for calculation]	(i) ARG: number of ARGs tested that confer resistance to main classes of antibiotics (e.g. beta-lactam, tetracycline, quinolone, sulfanamide and macrolide). (ii) ARB: number of ARBs tested that are clinically important.
Agency responsible for data collection	NEA, PUB
Baseline	Refer to One Health Report on Antimicrobial Utilisation and Resistance
Target	'By 2030, levels of relevant ARBs and ARGs in the sentinel environmental sites and water bodies are reported at least yearly.'
International alignment	Supports the commitment of the 2024 UNGA Political Declaration Para 78, to: 'Address research gaps and promote knowledge generation on the environmental aspects of antimicrobial resistance, including identifying appropriate methods for environmental surveillance, to inform the integration of environmental aspects in the development and

	implementation of national action plans on antimicrobial resistance as well as priority-setting and policymaking on antimicrobial resistance.’
Data limitations	-
Frequency of reporting	Annual
References	1. One Health Report on Antimicrobial Utilisation and Resistance, 2019. Singapore. 2. One Health Report on Antimicrobial Utilisation and Resistance, 2021. Singapore. 3. One Health Report on Antimicrobial Utilisation and Resistance, 2023. Singapore.

10. Indicator B8: One Health ESBL *E. coli*

Indicator name and number	Occurrence of (i) ESBL-producing *E. coli* and (ii) *E. coli* resistant to 3rd-generation cephalosporin across sectors as measured through One Health surveillance.
NSAP Goal 5	Timely and comprehensive picture of AMR and AMU within and across sectors.
Rationale for collection	This indicator takes reference from the global Tricycle Project and measures a single AMR phenotype across sectors. The global Tricycle Project (1) measures a single key sentinel or indicator organism, namely ESBL-Ec. While this indicator does not represent the overall global problem of AMR, the existing literature shows: (i) great variations in the rates of ESBL-Ec colonisation in humans in and between countries, and prevalence trends over time; (ii) variable prevalence among farm animals, with indications that some of the human morbidity linked to ESBL-Ec is due to antibiotic usage in the food chain, and the presence of ESBL-Ec in the environment; (iii) interventions leading to a decreased exposure to antibiotics in animals or humans have been followed by a decrease in ESBL-Ec occurrence rates; and (iv) ESBLs confer resistance to critically important antimicrobial drugs. Therefore, notwithstanding the fact that the comparison of these studies is sometimes difficult as different sampling schemes and methods have been used in the past, ESBL-Ec is a relevant and representative proxy for the magnitude and trends of the global AMR problem. *E. coli* resistant to 3rd-generation cephalosporin is included as an indicator for ESBL-Ec for comparison across sectors and populations, as ESBL-Ec is not routinely tested for in clinical specimens.
Definition(s)	• '*ESBL-producing E. coli', or ESBL-Ec, refer to* isolates of *E. coli* which produce extended spectrum beta-lactamase, as determined by internationally recognised (e.g. EUCAST or CLSI) methods. • '*E. coli resistant to 3rd-generation cephalosporins'*: E. coli isolates that are resistant as defined by current internationally recognised clinical breakpoints for third generation cephalosporins (e.g., EUCAST or CLSI), specifically ceftriaxone or cefotaxime or ceftazidime. • '*Occurrence*' may also refer to prevalence and incidence of the organism and/or resistance genes, subject to the unit of measurement appropriate for the surveillance target and sector. • '*Sectors*' refer to the human health, animal health, food, water and environment sectors. • '*One Health surveillance'*, or integrated AMR surveillance, in this context, refers to a national-level surveillance programme that collects, integrates, validates, analyses and reports on relevant microbiological and epidemiological data related to AMR in organisms of common concern across sectors.
Data sources (existing or potential)	CDA, NEA, NParks, PUB and SFA GLASS (2)
Method of measurement	The indicator will be measured through data obtained from (i) existing national surveillance programmes, which include active surveillance of food, the environment and healthy animals, and passive surveillance of clinical cases (human and animals); (ii) research studies, where needed.
Method of estimation	• Occurrence = the number of target isolates, as compared against the total number of samples. • Proportion of ESBL producers = the number of *E. coli* isolates which produce extended spectrum beta-lactamase, as compared against the total number of *E. coli* isolates from the population sampled.

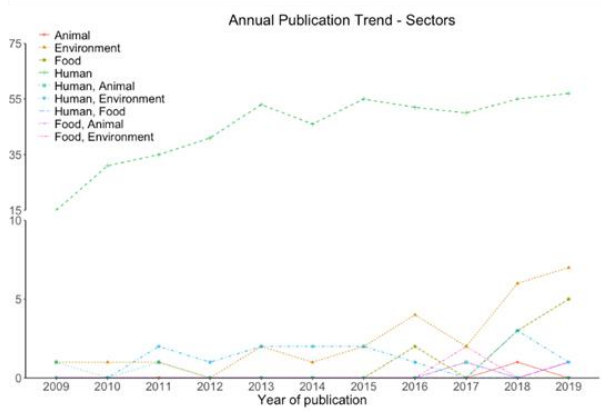
	• Incidence = $\frac{\text{Total No.of cases detected over the 6-month period}^{*}}{\sum \text{Hospital inpatient days for the same period}} \times 10{,}000$ • Other methods of estimation be established for this purpose.
Agency responsible for data collection	CDA, NEA, NParks, PUB, SFA
Baseline	Refer to One Health Report on AMR and AMU in Singapore.
Target	NA
International alignment	• Aligned with the Tricycle Project (1), adapted for the local situation. • GAP Indicator 2. g. Prevalence of ESBL producing indicator *E. coli* in animals: Resistance in commensal *E. coli* from key food producing animals, as follows: a: Percentage of *E. coli* isolates showing resistance to third-generation cephalosporins (i.e. presumptive ESBL-producing *E. coli*); b: Patterns of resistance in *E. coli* to a defined panel of antimicrobials.
Data limitations	• ESBL-Ec are not routinely tested for in clinical specimens unless specifically requested by physicians or veterinarians. As a result, the surveillance may underestimate the actual occurrence/incidence of ESBL-Ec in clinical populations, leading to potential underreporting. • Sampling in most cases leverages existing surveillance programmes designed for other purposes (e.g., disease surveillance, food safety). This may result in sample sets that are not representative of the true population or not randomised for AMR risk, limiting the ability to determine true prevalence. • Different sectors (e.g., human health, animal health, environment) may measure 'occurrence' using different criteria, definitions, laboratory methods, or sample types. These differences hinder direct comparisons and integrated interpretation across sectors. • Sampling may vary across different agencies. Small sample sizes in certain sectors (e.g. wildlife or environment) may limit statistical analysis and interpretation of the findings. • Differences in laboratory capabilities, culture media, or molecular methods across sectors may affect sensitivity and specificity in detecting ESBL-Ec and 3rd-generation cephalosporin-resistant *E. coli*.
Frequency of reporting	Annual
References	1. WHO integrated global surveillance on ESBL-producing *E. coli* using a "One Health" approach: implementation and opportunities. WHO, 2021. 2. World Health Organization. Global Antimicrobial Resistance Surveillance System (GLASS) websites: http://www.who.int/glass/en/

11. Indicator B9: One Health organisms

Indicator name	Occurrence and resistance of (i*) E. coli (ii) Salmonella spp (iii) Enterococci,* and other organisms of One Health concern across relevant sectors, against a defined panel of antibiotics.
NSAP Goal 5	Timely and comprehensive picture of AMR and AMU within and across sectors.
Rationale for collection	This indicator aims to monitor key drug-resistant organisms that occur across sectors, to assess transmission, linkages and risks.
Definition(s)	• '*Occurrence'* may also refer to prevalence and incidence of the organism and/or resistance genes, subject to the unit of measurement appropriate for the surveillance target and sector. • '*Sectors*' refer to the human health, animal health, food, water and environment sectors. • '*One Health surveillance'*, or integrated AMR surveillance, in this context, refers to a national-level surveillance programme that collects, integrates, validates, analyses and reports on relevant microbiological and epidemiological data related to antimicrobial resistance in organisms of common concern across sectors. • '*Resistance*' - Resistance against an antimicrobial agent is considered to be present if the minimum inhibitory concentration (MIC) exceeds the epidemiological cutoff value (CLSI definitions apply). Resistance here may also include resistant determinants and genes. • '*Defined panel of antibiotics'* refer to a common panel of antibiotics to be defined, agreed and adopted across the sectors. To be determined. • '*Other organisms of One Health concern'* – to be determined as needed according to national priorities. • '*Across relevant sectors'* refer to relevance to at least two sectors, according to national priorities.
Data sources (existing or potential)	CDA, NEA, NParks, PUB and SFA GLASS, FAO InFarm
Method of measurement	Antibiotic susceptibility testing using methods that measure the Minimum Inhibitory Concentration (MIC), applying CLSI M100 interpretative criteria. Other methods of measurement, e.g. detection of ARG, to be established for this purpose.
Method of estimation	Occurrence = the number of target isolates, as compared against the total number of samples. Incidence = $\frac{\text{Total No.of cases detected over the 6-month period}^{*}}{\sum \text{Hospital inpatient days for the same period}} \times 10{,}000$ % Resistance = [Number of resistant isolates / Total number of isolates tested] x 100 Other methods of estimation to be established for this purpose.
Agency responsible for data collection	CDA, NEA, NParks, PUB & SFA

Baseline	Not available. Pilot studies have been conducted and reported in the One Health Report on AMR and AMU (1-4).
Target	NA
International alignment	Aligned with GAP core outcome indicator III. Patterns and trends in resistance for indicator *E. coli* from priority food producing species:
Data limitations	• Populations sampled (e.g., hospitalised patients, livestock under veterinary care) may not represent the broader healthy human, animal, or environmental populations. • Different laboratories may use varied methods (e.g., MIC-based testing - VITEK AST, Sensititre system etc) and interpretative criteria (e.g., CLSI vs EUCAST), affecting comparability. • There may be inconsistent definition of "occurrence" and 'resistance" across sector, creating interpretation challenges. • The sampling or surveillance plan may be designed for specific organism or resistant type (e.g. targeting specific Salmonella serovars, or E. coli (ESBL-Ec). This may underestimate the baseline resistance rate. • Presence of resistance genes (e.g., *blaCTX-M*) does not always translate to phenotypic resistance (due to gene expression variability, silent genes). • In areas such as wildlife or environmental surveillance, resources for systematic AMR testing may be very limited, leading to under-reporting.
Frequency of reporting	The indicator will be measured through data obtained from (i) existing national surveillance programmes, which include active surveillance of food, the environment and healthy animals, and passive surveillance of clinical cases (human and animals); (ii) research studies, where needed.
References	1. One Health Report on AMR and AMU, 2017 2. One Health Report on AMR and AMU, 2019 3. One Health Report on AMR and AMU, 2021 4. One Health Report on AMR and AMU, 2023

12. Indicator B10: OH Research projects

Indicator name	Number of AMR research projects involving two or more sectors.
NSAP Goal 7	Increased AMR research relevant to local policy and practices.
Rationale for collection	AMR is a global human, environmental and veterinary public health issue, and Singapore is susceptible to the multi-pronged threat it poses. While transmission of AMR is interlinked across sectors, there are still gaps in the understanding of how this occurs, and the extent of the impact one sector has on another. A review of AMR research landscape in Singapore [1] from 2009 – 2019 showed an upward trend in the number of research articles published; however, the research landscape was observed to be fragmented, largely sector-specific and dominated by the human health sector. AMR research involving more than one sector was comparatively limited. As recognition of the importance of One Health increases, this indicator tracks the number of publications on cross-sectoral research on AMR.
Definition(s)	'Research projects' in this context refer to scientific publications of AMR studies conducted in Singapore, available on major scientific literature databases. 'Sectors' refer to the human, animal, food, water and environment sectors.
Data sources (existing or potential)	Major scientific literature databases, e.g. Global Health (Ovid), Scopus, Embase (Ovid), MEDLINE (Ovid), CINAHL (EBSCO), PubMed and Web of Science
Method of measurement	Search results from different databases combined in a single EndNote library to remove duplicated records. Preliminary screen of all titles and abstracts followed by full texts of articles retrieved and read in full and included based on pre-defined eligibility criteria[1].
Method of estimation	Number of papers meeting eligibility criteria for inclusion, calculated per year of publication.
Agency responsible	AMRCO CDA (For data collation and reporting)
Baseline	Refer to Poon et al, 2023[1] Bii 
Target	Increasing trend on cross-sectoral AMR research
International alignment	NA
Data limitations	Data may be limited by key words used in search. Relevant research not indexed in scientific databases searched may be excluded. Unpublished work and grey literature are also

	excluded. Due to the lack of agreed definitions for the sectors globally, articles are also categorised using self-defined sectors.
Frequency of reporting	To be determined
References	1. Poon S, Goh DM, Khoo A, Lin YN, Leo YS, Lee TH. Antimicrobial resistance research in Singapore - mapping current trends and future perspectives. medRxiv. [Online] 2023. https://doi.org/10.1101/2023.11.28.232991.

13. Indicator B11: Vaccination against flu and S. pneumoniae

Indicator name and number	Proportion (%) of target population that is vaccinated against (i) influenza and (ii) *Streptococcus pneumoniae*
NSAP Goal 10	Increased uptake of vaccination and alternatives to reduce reliance on antimicrobials.
Rationale for collection	This indicator serves to monitor the uptake of relevant vaccinations and the effectiveness of campaigns to promote vaccination, especially among older adults. Vaccination plays an important role in the fight against AMR by helping people build up immunity against certain bacterial or viral infections, thereby reducing the risk of infection and need for antibiotics. Influenza and pneumococcal are vaccines recommended under the National Adult Immunisation Schedule.
Definition(s)	• '*Target population'* refers to older Singapore residents aged 65 - 74 years of age. • '*Vaccinated*' means having received the last recommended dose of the vaccine. • '*Influenza*' refers to infections caused by influenza virus types A and B.
Data sources (existing or potential)	Ministry of Health; National Population Health Survey; other surveys
Method of measurement	Administrative reports where the number of individuals in the target group that has received each vaccine is the numerator and the target population is the denominator or household surveys. National Population Health Survey methodology
Method of estimation	Numerator: The number of individuals in the target group for each vaccine that has received the last recommended dose. Denominator: The total number of individuals in the target group for each vaccine.
Agency responsible	CDA
Baseline	(i) Influenza: 32.4% of residents aged 65 – 74 (1) (ii) Pneumococcal: 22.4% of residents aged 65 – 74 (self-reported)
Target	NA
International alignment	Aligned with GAP Indicators: 3.2. Immunisation coverage: Percentage of the target population that has received the last recommended dose of the basic series for each of the following vaccines: (i) pneumococcal conjugate vaccine. and Immunisation coverage for (b): Influenza
Data limitations	Self-reporting may be influenced by recall failures.
Frequency of reporting	Yearly
References	-

14. Indicator B12: Human AMU/AMC (country level)

Indicator name and number	Total human consumption of antimicrobials for systemic use, by type and class, measured in (a) Daily defined dose (DDD) and (b) DDD per 1000 inhabitants per day (DID).
NSAP Goal 5	Timely and comprehensive picture of AMR and AMU within and across sectors.
Rationale for collection	The collection of data on antimicrobial use or consumption is important to provide comprehensive information on overall utilisation in the human health sector.
Definition(s)	• '*Total antimicrobial consumption'* here refers to the total aggregated estimate of consumption at the country level. As defined by GLASS[1], antimicrobial consumption (AMC) data refer to estimates derived from aggregated data sources such as import or wholesaler data, or aggregated health insurance data, which provide no information available on the patients who receive the medicines or why the antimicrobials are being used. These data sources provide a proxy estimate of antimicrobial use. Consumption data may be presented as total consumption for a country or may be disaggregated by health care setting (community or hospital, and public or private sectors). • '*Antimicrobials for systemic use'* refer to the following antimicrobials monitored by GLASS, such as Anatomical Therapeutic Chemical (ATC) classification codes J01, A07AA, P01AB. Optional: J02, D01BA, J05, J04A and P01B. [1] • '*Type*' refers to the active ingredient e.g. amoxicillin, cephalexin, enrofloxacin. • '*Class*' to the class of antimicrobial, e.g. penicillin, macrolide, fluoroquinolone • '*Defined Daily Dose'* refers to the assumed average maintenance dose per day for a drug used for its main indication in adults, as defined by WHO.
Data sources (existing or potential)	GLASS-AMU; CDA (AMRCO)
Method of measurement	Retrospective data collection as per GLASS Methodology for surveillance of national antimicrobial consumption, 2020[1]: (i) Antimicrobial consumption data refer to estimates derived from aggregated data sources such as import or wholesaler data, or aggregated health insurance data where there is no information available on the patients who are receiving the medicines or why the antimicrobials are being used. These data sources provide a proxy estimate for the use of antimicrobials. Consumption data may be presented as total consumption for a country or may be disaggregated by setting (community or hospital; public or private sectors). (ii) Antimicrobial use data refer to estimates derived from patient-level data. Such data may allow disaggregation of data based on patient characteristics (gender, age), or indication for which the medicine is being used.
Method of estimation	a. Number of DDDs = Total grams used / DDD value in gram b. Number of DIDs = [DDD / inhabitants / days in the year] x 1000 Where, Number of Inhabitants is the population of Singapore as published by United Nations, for the year of measurement.

	Note: For alignment with GLASS-AMU, the UN population statistics will be used instead of that published by Singstats.
Agency responsible	CDA
Baseline	Total antimicrobial consumption in 2023 was estimated at 9.43 DID based on private market research sales data (GLASS-AMU, 2023).[2]
Target	NA
International alignment	GAP Indicator 4.1. Use of antimicrobials in humans: (a) Total human consumption of antibiotics for systemic use (Anatomical Therapeutic Chemical classification code J01) in Defined Daily Doses per 1000 population (or inhabitants) per day.[3]
Data limitations	Sales of generic drugs, which constitute a substantial component of antimicrobial use, are under-represented in private market research antimicrobial sales data.
Frequency of reporting	Annual
References	2. WHO 2020. GLASS methodology for surveillance of national antimicrobial consumption. 3. GLASS-AMU 2025 Report (2023 data), www.who.int 4. WHO, FAO and OIE, 2019. Monitoring and evaluation of the global action plan on antimicrobial resistance: framework and recommended indicators.

15. Indicator B13: Access group antimicrobials

Indicator name and number	**(i)**	**Proportion of Access category antimicrobials for systemic use, relative to total antimicrobial consumption in Defined Daily Doses**
	(ii)	**Proportion (%) of polyclinic and GP clinic antimicrobial prescriptions that comprise antimicrobials in the Access category of the WHO AWARE classification.**
NSAP Goal 13	Evidence-based and prudent use of antimicrobials is supported by regulatory controls and professional oversight.	
Rationale for collection	The Access, Watch and Reserve (AWaRe)[1] classification of antibiotics was developed by the WHO Expert Committee on Selection and Use of Essential Medicines as a tool to support antibiotic stewardship efforts. It provides evidence-based guidance on the choice of antibiotic, dose, route of administration, and duration of treatment for several conditions. The 2024 Political Declaration on AMR set a global target to achieve at least 70% of antibiotic use from the 'Access' group, which are antibiotics that are recommended as empiric first or second-choice treatment options and which have generally low resistance potential. The tracking of the proportion of antimicrobial prescriptions using the AWaRe classification is intended to guide appropriate antimicrobial prescribing.	
Definition(s)	• '*AWaRe classification'* refers to the Access, Watch and Reserve (AWaRe) classification of antibiotics developed by the WHO Expert Committee on Selection and Use of Essential Medicines as a tool to support antibiotic stewardship efforts.[1] • '*Access category antimicrobials'* refers to the antibiotics recommended by WHO as empiric first or second-choice treatment options and which have generally low resistance potential, as listed in the AWaRe classification scheme[1]. • 'Total antimicrobial consumption' here refers to the total aggregated estimates for the country in DDD, as measured by Indicator C1. • '*Defined Daily Dose'* is the assumed average maintenance dose per day for a drug used for its main indication in adults, as assigned by WHO. • '*Polyclinic'* refers to an outpatient public healthcare facility in the primary care sector licensed by MOH. • '*GP clinic'* refers to an outpatient private general practitioner clinic in the primary care sector licensed by MOH. • '*Antimicrobial prescription'* refers to the dispensing of antimicrobials (antibiotics, antivirals, antiparasitics and antifungals) from medical practitioners.	
Data sources (existing or potential)	(i) GLASS AMC (ii) AMRCO (CDA)	
Method of measurement	Retrospective data collection as per GLASS Methodology for surveillance of national antimicrobial consumption, 2020 [2]	
	(i) Percentage of annual total antimicrobial reported sales in DDD in the human health sector (indicator C1) that are classified under the 'Access' category of the WHO AWaRe classification, according to GLASS methodology.	
	(ii) Percentage of annual total antimicrobial utilisation by polyclinic and GP clinics that are classified under the 'Access' category of the WHO AWaRe classification, measured in DDD per 100 Doctor Visits.	

Method of estimation	(i) [Total sales in DDD of Access category antimicrobials] / [Total reported sales in DDD of all antimicrobials] x 100 Where antimicrobials refer to those ATC codes monitored by WHO GLASS AMC. (ii) [Total utilisation of antimicrobials under the Access category antimicrobials / Total utilisation of antimicrobials by sentinel clinics] x 100
Agency responsible	CDA
Baseline	Approx 60% (GLASS AMC, 2023)
Global Target	At least 70% of antimicrobials prescribed should be of the Access category.[2]
International alignment	• 2024 UNGA HLM Political Declaration on AMR [3] • GAP Indicator 4.1 Use of antimicrobials in humans: b: Proportion of Access antibiotics for systemic use, relative to total antibiotic consumption in Defined Daily Doses.[4]
Data limitations	• Sales of generic drugs, which constitute a substantial component of antimicrobial use, are under-represented in private market research antimicrobial sales data. • Data from GP clinics are contributed by a limited number of sentinel clinics participating in AMRCO's surveillance initiative and may not be representative of all primary care utilisation patterns.
Frequency of reporting	Annual
References	1. AWaRe classification of antibiotics for evaluation and monitoring of use, 2023 (www.who.int) 2. GLASS Methodology for surveillance of national antimicrobial consumption, 2020 3. UNGA Political Declaration on AMR, 2024, para 64. 4. WHO, FAO and OIE, 2019. Monitoring and evaluation of the global action plan on antimicrobial resistance: framework and recommended indicators.

16. Indicator B14: ASP in healthcare facilities.

Indicator	Number of acute hospitals implementing antimicrobial stewardship programmes (ASP).
NSAP Goal 13	Evidence-based and prudent use of antimicrobials is supported by regulatory controls and professional oversight.
Rationale for collection	This indicator monitors the progress of implementation of ASP in acute hospitals, in order to strengthen the appropriate use of antimicrobials in healthcare.
Definition(s)	'*Acute hospitals'* are healthcare facilities licensed and classified as acute hospitals by the Ministry of Health, Singapore [1]. These comprise both general hospitals and specialty centres (excluding psychiatric hospitals) with acute care inpatient facilities. '*Antimicrobial stewardship programme'* is a structured programme that aims to improve and optimise the use of antimicrobials. '*Implementing*' refers to having put in place a set of actions that fulfill the minimum requirements to be set out by a national body and report specified indicators on a six-monthly basis to the National AMR Control Committee (NARCC).
Data sources (existing or potential)	NARCC
Method of measurement	Measured under the NARCC framework.
Method of estimation	Number of acute hospitals that report specified ASP indicators* to NARCC. (*to be determined)
Agency responsible	CDA
Baseline	In 2024, 10 out of 19 (53%) of acute hospitals had implemented ASPs.
Target	By 2030, ASPs are implemented in all acute care hospitals.
International alignment	(i) GAP indicator (Annex 2): Percentage of acute health care facilities with an antimicrobial stewardship programme in place'[2] (ii) TrACSS (2024) Q3.6 Score D 'National guidelines for appropriate use of antimicrobials are available and antimicrobial stewardship programs are being implemented in most health care facilities nationwide. Monitoring and surveillance results are used to inform action and to update treatment guidelines and essential medicines lists.'[3]
Data limitations	Limitation on comparability: ASPs in public and private acute hospitals may differ due to differences in structure and operating models.
Frequency of reporting	Annual (TrACSS)
References	1. www.moh.gov.sg/others/resources-and-statistics/health-facilities 2. WHO, FAO and OIE, 2019. Monitoring and evaluation of the global action plan on antimicrobial resistance: framework and recommended indicators. 3. WHO, FAO, WOAH, UNEP. Tracking AMR Country Self-assessment Survey.

17. Indicator B15: Guidelines developed

Indicator name	Number of antibiotic prescribing guidelines for common infections treated in primary care developed and disseminated.
NSAP Goal 13	Evidence-based and prudent use of antimicrobials is supported by regulatory controls and professional oversight.
Rationale for collection	More judicious use of antibiotics is needed in primary care. Antibiotic use guidelines will help guide more appropriate prescribing for infections commonly treated in primary care. This indicator will monitor the number of guidelines developed for primary care.
Definition(s)	• '*Antibiotic prescribing guideline'* refers to a guideline developed to guide antibiotic treatment of a specified infection. • '*Common infections'* refer to the list of infections commonly treated by primary care physicians in Singapore, identified in consultation with local GPs. • '*Primary care'* refers to polyclinics and private GP clinics licensed and identified as such by MOH, Singapore. • '*Developed*' is when the guideline has been approved by the relevant authority and/or body for circulation and use. • '*Disseminated*' is when the guideline has been circulated to all primary care clinics, via physical or electronic means.
Data sources (existing or potential)	AMRCO (CDA)
Method of measurement	Administrative records
Method of estimation	NA
Agency responsible	CDA
Baseline	No of guidelines developed and disseminated: 1 (URTI)
Target	By 2030, antibiotic prescribing guidelines for at least 7 common primary care infectious disease conditions are developed and disseminated.
International alignment	TrACSS (2024) 3.6 -Score E 'National guidelines on optimizing antibiotic use are implemented for all major syndromes and data on use is systematically fed back to prescribers.'
Data limitations	-
Frequency of reporting	To be determined
References	-

18. Indicator B16: Registration and approval of antimicrobials for animal use

Indicator name and number	Number of antimicrobials approved for animal use that have undergone safety, efficacy, and quality evaluations.
NSAP Goal 12	Sustained access to essential, safe and effective antimicrobials to treat infections.
Rationale for collection	The use of poor-quality and inefficacious antimicrobials contributes to the development of AMR. When initial treatments fail due, additional courses may be prescribed, increasing overall antimicrobial use and exposure, further driving AMR development. This indicator will monitor the implementation of the regulatory framework that ensures that veterinary medicinal products containing antimicrobials for use in Singapore are safe and efficacious.
Definition(s)	• 'Antimicrobial products' in this context refers to veterinary medicinal products containing antimicrobial agents (antibiotics, antifungals, antivirals) that are intended for use in animals in Singapore. • 'Approved' refers to approval by NParks as the Competent Authority and inclusion into a register of approved products set up for this purpose. • 'Evaluation' refers to the process in which the Competent Authority reviews information on the quality, safety and efficacy of an antimicrobial provided by a company to determine whether it may be approved for import, sale and use in the country. (This excludes the off-label use of Therapeutic Products in animals and the discretionary cases of import of unapproved antimicrobials by veterinarians for last-line use.)
Data sources (existing or potential)	NParks
Method of measurement	Administrative records of registered veterinary medicinal products containing antimicrobials.
Method of estimation	Number of antimicrobial products for animal use that have undergone NParks' evaluation of safety, efficacy, and quality, and are approved and registered for import, sale and use in Singapore. Discretionary cases of import of unapproved antimicrobials by veterinarians for last-line use are excluded.
Agency responsible for data collection	NParks
Baseline	No antimicrobials have been evaluated and approved for animal use thus far.
Target	By 2030, a regulatory framework for antimicrobial use in the animal sector is established, including regulatory levers to ensure they are safe, effective and only supplied through prescription.
International alignment	GAP Indicator 4.a Regulatory framework for veterinary medicinal products: Countries that have a regulatory framework for veterinary medicinal products (including medicated feed) that covers all stages of the cycle (manufacture, supply, sale, use, disposal) and meets other requirements in the OIE and Codex Alimentarius standards
Data limitations	-

Frequency of reporting	Annual
References	-

19. Indicator B17: Veterinary AMU (country level)

Indicator name	Country level AMU: (i) Antimicrobial sales for veterinary use, by type, class and sector, measured in kg; and (ii) Proportion of wholesalers reporting data.
NSAP Goal 5	Timely and comprehensive picture of AMR and AMU within and across sectors.
Rationale for collection	Antimicrobial sales data, while not directly equating to use, serves as a useful proxy for AMU. It's more accessible than direct usage data, reveals trends over time, and can indicate shifts in usage practices early on.
Definition(s)	• '*Antimicrobial sales'* refer to the quantity (by weight of active ingredients) of antimicrobials sold in Singapore per year. • '*Veterinary use'* means use in animals or administered to animals for therapeutic purpose. • '*Type*' refers to the active ingredient e.g. amoxicillin, cephalexin, enrofloxacin. • '*Class*' to the class of antimicrobial, e.g. penicillin, macrolide, fluoroquinolone • '*Sector'* here refers to the different animal sectors as categorised by ANIMUSE[1], i.e. companion animal (including equines), terrestrial livestock, aquaculture sectors. Aquaculture includes ornamental fish. • '*Wholesalers*' refer to Singapore-registered companies which purchase antimicrobials for sale to retailers. • '*Wholesalers reporting data'* refer to the companies that respond to a voluntary annual survey on sales of antimicrobials for veterinary use.
Data sources (existing or potential)	NParks
Method of measurement	Annual wholesaler survey
Method of estimation	(i) WOAH ANIMUSE survey, Reporting Option 3[1-2] (ii) Proportion = [Number of wholesalers responding to the survey / Number of wholesalers surveyed] x 100
Agency responsible	NParks
Baseline	(i) Antimicrobial sales to the veterinary sector in 2023 was 1103 kg. For breakdown by class, type and sector, refer to the One Health Report on Antimicrobial Utilisation and Resistance, 2023.[4] (ii) Proportion of wholesalers reporting data in 2021 was ~73% (41/56 companies)[3]
Target	NA
International alignment	GAP Indicator 4.5 (a) Levels and trends in sales/imports/use of antimicrobials in food producing animals.[5]
Data limitations	• This reporting of sales data is voluntary, and therefore the quantity reported may be an underestimation of actual sales data. • Accuracy of data reported is wholly dependent on the companies, with no means of verification. Sales does not equate to use. This data can only be used as a proxy for AMU.

	• The number of wholesalers reporting data may vary from year to year.
Frequency of reporting	Annual
References	1. WOAH ANIMUSE (https://amu.woah.org) 2. Terrestrial code – http://www.oie.int/en/standard-setting/terrestrial-code/access-online/ • AMU – Chapter 6.9. "Monitoring of the quantities and usage patterns of antimicrobial agents used in food-producing animals" Aquatic code – http://www.oie.int/en/standard-setting/aquatic-code/access-online/ • Chapter 6.3 – Monitoring of the quantities and usage patterns of antimicrobial agents used in aquatic animals. 3. One Health Report on Antimicrobial Utilisation and Resistance, 2021 4. One Health Report on Antimicrobial Utilisation and Resistance, 2023 (in preparation) 5. WHO, FAO and OIE, 2019. Monitoring and evaluation of the global action plan on antimicrobial resistance: framework and recommended indicators.

20. Indicator B18: HP-CIA and Fluoroquinolone/Quinolone sales

Indicator name	(i) Percentage of total sales classified as WHO Highest Priority Critically Important Antimicrobial agents (HP-CIAs). (ii) Quantity of sales of fluoroquinolones / quinolones to farms, in kg.
NSAP Goals 5 & 13	• Timely and comprehensive picture of AMR and AMU within and across sectors. • Evidence-based and prudent use of antimicrobials is supported by regulatory controls and professional oversight.
Rationale for collection	The antimicrobial classes categorised by WHO[1] as HPCIAs are: Cephalosporins (3rd and 4th generation), quinolones (including fluroquinolones), polymyxins, phosphonic acid derivatives. Unlike in the companion animal sector where the use and administration of antimicrobials are subject to veterinarian oversight, the use of antimicrobials in farms (both food-producing and non-food-producing) is largely left up to the farmers, who may not be as aware of the risk of misuse of antimicrobials. Amongst the HPCIA classes, quinolones are the class of antimicrobials most sold to and used by farmers. There were no sales of cephalosporins (3rd and 4th generation), polymyxins (which are banned) or phosphonic acid derivatives to farmers in recent years. As such, tracking quinolone sales will help to elucidate usage patterns and potentially guide policy decisions.
Definition(s)	• '*Percentage of total sales'* refers to the percentage of kilograms of antimicrobials intended for use in animals that are classified as the WHO Highest Priority Critically Important Antimicrobial for Human Medicine [1]. • '*Sales*' refers to the quantities (by weight of active ingredient) of antimicrobials sold in Singapore for veterinary use, as reported by wholesalers participating in a voluntary annual survey. • '*WHO Highest Priority Critically Important Antimicrobial agents (HP-CIAs*)' are antimicrobials identified by WHO as last resort antimicrobials critical to human health that should only be used when no other antimicrobial is effective.[1] • '*Quinolones'* refer to antimicrobial agents classified under the ATC code J01M or ATC vet code QJ01M. • '*Farms*' refer to terrestrial livestock and aquaculture farms in Singapore, and includes food-producing and non-food-producing. Aquaculture includes ornamental fish farms. Farms exclude pet breeding farms.
Data sources (existing or potential)	NParks
Method of measurement	Quantity of sales (in kg) for terrestrial Livestock and aquaculture sectors are measured through an annual wholesaler survey. Data aggregated and reported using WOAH ANIMUSE survey Reporting Option 3[2].
Method of estimation	(i) Numerator: Total kilograms of Highest Priority Critically Important Antimicrobial Agents reported. Denominator: Total kilograms of antimicrobial agents reported. According to the WHO Highest Priority Critically Important Antimicrobial for Human Medicine. (ii) Kilograms (kg) of all quinolones/fluoroquinolones sold to farms.
Agency responsible for data collection	NParks

Baseline	HP-CIA sales Quinolone sales to the farm (food-producing and non-food-producing) sector in 2023 was 248kg. [3]
Target	By 2030, the quantity (kg) of sales of fluoroquinolones to farms is reduced.
International alignment	(i) GAP Indicator 4.5 Levels and trends in sales/imports/use of antimicrobials in food producing animals: (b) Percentage of total sales/imports (or use) classified as WHO Highest Priority Critically Important Antimicrobial agents. (ii) UNGA Political Declaration on AMR, 2024, para 6: 'Strive to meaningfully reduce, by 2030, the quantity of antimicrobials used globally in the agrifood system from the current level, taking into account national contexts,'
Data limitations	• This reporting of antimicrobial sales data is voluntary, and therefore the quantity reported may be an underestimation of actual sales data. • Accuracy of data reported is wholly dependent on the companies, with no means of verification. Sales does not equate to use. This data can only be used as a proxy of AMU. • The number of wholesalers reporting data may vary from year to year.
Frequency of reporting	Annual
References	1. WHO 2024. WHO List of Medically Important Antimicrobials: a risk management tool for mitigating antimicrobial resistance due to non-human use. 2. ANIMUSE. https://amu.woah.org 3. One Health Report on Antimicrobial Utilisation and Resistance in Singapore, 2023

ANNEX C: NSAPv2 AND M&E FRAMEWORK DEVELOPMENT

The second National Strategic Action Plan (NSAPv2) and corresponding Monitoring and Evaluation (M&E) Framework were developed by the One Health AMR Workgroup (OH AMRWG). The AMRWG comprises director and technical-level representatives of CDA, NEA, NParks, PUB and SFA, supported by the AMRCO (CDA) as Secretariat.

From late 2022 to mid-2024, four platforms were used to gather input for drafting the NSAPv2 and M&E Framework:

1. An internal review led by AMRCO
2. A commissioned evaluation conducted by the Health Intervention and Policy Evaluation Research (HIPER) unit of National University of Singapore.
3. A multi-sectoral workshop to brainstorm goals, targets and indicators for monitoring.
4. Review of local studies to gather evidence and recommendations for actions.

1. Internal Review Methodology

The Review solicited views from the implementing agencies and committees concerning the strengths and gaps of the first NSAP and its implementation challenges. This was conducted from December 2022 to March 2023 in the form of a questionnaire sent to One Health agencies and to the MOH-appointed committees: National AMR Control Committee (NARCC), National Antimicrobial Stewardship Expert Panel (NASEP), National Antimicrobial Resistance Expert Panel (NAREP) and National Infection Prevention and Control Committee (NIPC). Participants were asked the following questions:

a. Since its launch in 2017, do you think the NSAP has advanced our efforts to address the problem of AMR in Singapore?
b. What do you think are the gaps and weaknesses of the current NSAP?
c. What outcomes should the NSAP produce for Singapore?
d. What other actions need to be taken to better control AMR in Singapore?
e. What challenges did you face in implementing the NSAP initiatives?

Responses submitted via email or an online portal (FormSG) to the AMRCO were compiled into a report submitted to the OH AMRWG. Inputs were used by AMRCO to craft proposed goals and mission statements for discussion, and to develop the initial NSAPv2 draft.

2. HIPER Evaluation Methodology

The *Evaluation of the NSAP on AMR in Singapore (2017-2023)* was conducted from April to November 2023 as a qualitative study integrating viewpoints from policymakers, implementation agencies and actors “on the ground” across the One Health sectors. Of the total 60 participants recruited, human sector participants formed the largest number, followed by animal, food, and lastly water and environment sectors. The policy audience comprised 61% (n= 37) of participants with the remaining being on-the-ground actors (Table 1).

Qualitative data was gathered mainly through 12 Focus Group Discussions (FGDs) involving 57 participants. In-depth interviews were held for three participants for whom FGDs were not feasible. All One Health sectors were represented for the policy audiences, including the

AMRCO and AMRWG. On-the-ground participants included public hospital staff, primary care doctors, veterinarians, pet breeders, industry professionals (ornamental fish industry) and food fish farmers. As no land-based farmers or food distributors could be recruited, the research team relied on agency and wider industry perspectives.

Participants were encouraged to share their experiences and perspectives on the five NSAP pillars. Audio-recordings were transcribed verbatim and uploaded into ATLAS.ti which was used to manage the data and facilitate coding and analysis. The findings and recommendations by the HIPER research team were provided to the OH AMRWG in the form of a report and presentation.

Table 1. Spread of participants recruited across policy and ground levels by sector

		Human	Animal	Food	Water & Environment	One Health	Total
Policy level	AMRWG senior managers representing One Health cross-sector initiatives	4	1	1	1	N/A	7
	AMRCO	-	-	-	-	6	6
	One Health agencies	7	5	7	5	N/A	24
On the ground	Hospital (public)	4	N/A	N/A	N/A	N/A	4
	Primary Care (private)	4	N/A	N/A	N/A	N/A	4
	Veterinarians (private)	N/A	5	N/A	N/A	N/A	5
	Animal and food industry (private)	N/A	2	8	N/A	N/A	10
	Total	19	13	16	6	6	60

3. Identification of Goals, Targets and M&E Indicators

A multi-sectoral workshop was convened in May 2024 to brainstorm proposals for targets and indicators. Participants included representatives from One Health agencies involved in policy, regulatory, surveillance and fieldwork in the human, animal, food and environment sectors, AMR researchers and a healthcare infection control expert. The workshop included public sector healthcare and veterinary professionals, as well as two private sector general practitioners.

Workshop participants first discussed the proposed goal statements and provided suggestions for improvement. These goals then guided the development of targets and indicators. Based on the criteria for targets and indictors to be SMART (Specific, Measurable, Achievable, Relevant and Timebound), drive concrete action and distributed across all sectors, participants were asked to brainstorm for possible targets to achieve and indicators that could measure progress towards desired goals. Where relevant, targets should be aligned with the commitments of the UNGA Political Declaration on AMR.

From an initial list of 115 suggestions for targets, the final eight were selected after two rounds of shortlisting, in-depth assessments and consultations. Targets were shortlisted via two rounds of scoring (from 1 – 5 based) based on a set criteria related to relevance, clarity and ambition, using an adapted Delphi method for prioritisation. Targets with low mean scores and high standard deviations were eliminated. Twenty-two indicators were similarly

short-listed from an initial list of 64 indicators, applying criteria related to relevance, clarity and specificity.

To assess feasibility, in-depth discussions on the human health targets with the NARCC, NASEP, NAREP, NIPC and the CDA senior management. Private sector veterinarians and industry professionals were also consulted on targets related to animal and food production. Discussions on environmental targets were held between NEA and PUB to ensure alignment between the water and environment agencies. Original proposals were further refined following consultations to ensure clarity and achievability by 2030.

Detailed technical sheets were drawn up to ensure that proposed indicators could be defined and measured. Further refinement and prioritisation resulted in 20 indicators being selected for monitoring and evaluation.

Target and Indicator Technical Sheets are found in Annexes A and B respectively.

4. Literature review

We examined publications related to analyses of Singapore's strategy, AMR situation as well as knowledge, attitudes and practices of Singapore's residents and professionals. Evidence presented and authors' recommendations were reviewed for relevance to addressing the gaps identified in the internal review and third-party evaluation.

Drafting and Approval of the NSAPv2 and M&E Framework

The NSAPv2 was planned with an outcome-based approach, hence goals, targets and M&E indicators were developed in tandem. The internal review found that implementers favoured some consistency with the first NSAP, hence the five core strategies were retained but updated and expanded in scope to meet evolving needs. Recommendations arising from the above four platforms guided the development of broad initiatives under each core strategy. Various initiatives were also developed to fulfil the targets set for 2030.

The completed draft NSAPv2 was circulated for review by the One Health agencies, ACE MOH, NARCC, NASEP, NAREP, NIPC, the College of Family Physicians Singapore, the Chapters of Infectious Disease Physicians and Family Medicine Physicians of the Academy Medicine, Singapore, the Pharmaceutical Society of Singapore and the Singapore Veterinary Association. Post-consultation, the final drafts of the NSAPv2 and the M&E Framework were submitted for approval by the One Health agencies and parent ministries, i.e. Ministry of Health, Ministry of National Development and Ministry for Sustainability and the Environment.