

Thailand's National Strategic Plan on Antimicrobial Resistance 2017–2021



Executive summary

Antimicrobial medicines, especially antibacterial agents, are essential to medical care and public health. As well as having a vital role in reducing morbidity and mortality in individuals who present with bacterial infections, they are also important for the prevention of infections associated with surgery, organ transplantation and chemotherapy. Antimicrobials are also essential for the prevention and treatment of infectious diseases in veterinary practice and agriculture including the livestock industry and in fisheries; they are also used in crop production. They are therefore important for the food production chain and for the national economy.

In recent years, the problem of antimicrobial resistance (AMR), especially resistance to antibiotics, has increased significantly. Unless drastic action is taken, it is expected that this trend will continue. The further spread of resistance threatens the effectiveness of existing antimicrobials: a situation that is compounded by a lack of incentives for the pharmaceutical industry to invest in research and development of new antibiotics. The concern is therefore that the world is heading towards a post-antibiotic era in which simple bacterial infections may become more lethal. This scenario also threatens the practice of modern medicine and could lead to a situation where important medical procedures such as those listed above can no longer be safely performed.

Globally, AMR is believed to cause approximately 700,000 deaths per year. It has also been estimated that failing to tackle AMR could cause 10 million deaths a year and cost up to 100 trillion USD by 2050. The highest impact is also likely to be found in Asia and Africa, accounting for 4.7 and 4.2 million deaths respectively. In Thailand, a preliminary study on the burden of AMR has revealed that AMR causes approximately 38,000 deaths annually and that overall economic losses due to AMR are as much as 1,200 million USD.

In 2014, the Ministry of Public Health undertook a consultation with stakeholders in all concerned sectors to assess the national status of AMR management. The results indicated that while Thailand has the systems and

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infrastructure to address AMR, a lack of specific national policy on AMR had resulted in suboptimal coordination and unclear goals and objectives.

In 2015, the Ministry of Public Health appointed a Coordinating and Integrating Committee on AMR. The Committee consists of representatives from the Ministry of Public Health and the Ministry of Agriculture and Cooperatives as well as academia, professional societies and civil society organizations. Its most important role was to develop for Thailand the first National Strategic Plan on Antimicrobial Resistance as a national framework for relevant multi-sectoral stakeholders to join hands in addressing the country's AMR issues.

In 2016, this National Strategic Plan on Antimicrobial Resistance 2017-2021 was completed with the vision of reducing the morbidity, mortality and economic burden caused by AMR. Its goals are that by the year 2021, morbidity caused by AMR will reduce by 50%; antimicrobial consumption in human and animals will reduce by 20% and 30% respectively; public knowledge on AMR and awareness on the appropriate use of antimicrobials will increase by 20%; and national AMR management systems will comply with international criteria.

In order to achieve these goals, the development of Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021 is based on three underlying principles: (1) it needs to be an action-oriented strategic plan with measurable outcomes; (2) it needs to be a synergized and orchestrated strategic plan in order to consolidate multi-sectoral efforts; and (3) it needs to be a strategic plan to stimulate political commitment as a key factor leading to the resolution of AMR issues and the allocation of appropriate resources to address AMR issues effectively and sustainably.

Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021 consists of 6 strategies as follows.

Strategy 1 AMR surveillance system using a 'One-Health' approach

Strategy 2 Regulation of antimicrobial distribution

Strategy 3 Infection prevention and control and antimicrobial stewardship in humans

Strategy 4 AMR prevention and control and antimicrobial stewardship in agriculture and animals

Strategy 5 Public knowledge on AMR and awareness of appropriate use of antimicrobials

Strategy 6 Governance mechanisms to develop and sustain AMR-related actions

Strategies 1-5 aim at resolving different aspects of AMR in an integrated manner. Strategy 6 aims at developing structures and mechanisms to implement Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021.

Monitoring and evaluation of the implementation of Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021 will be based on the developmental evaluation approach, including the measurement of progress towards defined National Strategic Plan milestones, targets and goals in reference to an established baseline.

The National Strategic Plan on Antimicrobial Resistance 2017-2021 is Thailand's first national strategy that is specifically targeted towards addressing AMR issues. It sets clear and measurable goals as well as establishing an integrated framework to resolve AMR issues. It is also responsive to the national situation with an emphasis on multi-sectoral collaboration through the One Health approach and takes into account both national and international policies in order to systematize actions to address AMR. Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021 is also aligned with the Global Action Plan, reflecting the country's commitment to join forces internationally in resolving AMR issues.

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Operational definitions

Operational definitions

Antimicrobial resistance (AMR)

AMR refers to the ability of microbes (e.g. bacteria, viruses and fungi) to grow or survive even after exposure to antimicrobial agents at concentrations that are normally sufficient to inhibit or kill that particular strain of the organisms. In this strategic plan, AMR predominantly means AMR in bacteria.

Antimicrobial agent

Antimicrobial agents are those that have antimicrobial properties or the ability to inhibit growth or metabolic processes in microbes (e.g. bacteria, viruses and fungi). They are obtained from living organisms or through synthesis. In this strategic plan, antimicrobial medicines predominantly means antimicrobial medicines with bactericidal properties, including those with the ability to stop bacterial growth.

Antibiotic

Antibiotics are antimicrobial medicines with bactericidal properties, (including those with the ability to stop bacterial growth), obtained from living organisms or through synthesis. Examples include penicillin, amoxicillin, tetracycline, norfloxacin and azithromycin. The terms microbicide (microbe killer), antibacterial medicines, and antibiotics are used interchangeably.

Antimicrobial stewardship

Prudent and responsible management of antimicrobial medicine use that focuses on systematic coordination of inter-professional efforts in the provision of patient care, thereby enabling appropriate selection of antimicrobial medicines for treatment (type, dosage, commencement, direction and treatment duration). This ensures that antimicrobial medicines are most appropriately administered for prevention and treatment of infection, leading to minimal undesirable side effects, minimal impact on AMR and potential subsequent AMR spread, and reduction in unnecessary economic loss.

Health literacy

The ability and skill to access information, knowledge and understanding used to analyze, interpret and assess health service information and news received from external sources. This motivates individuals to make better decisions on methods of self-care and personal health management in order to continually maintain good health as well as give advice and promote good health to other individuals, families and communities.

Scope of the Strategic Plan

Thailand's National Strategic Plan on Antimicrobial Resistance 2017–2021 focuses mainly on AMR management in bacteria given the urgency and the widespread impact of the problem – as well as the absence to date of a dedicated national strategy to address the issue in an integrated manner.

In the past, Thailand has had national policies and strategies to address AMR in relation to specific diseases, for example, TB, malaria and AIDS. Nonetheless, national policies or strategies that specifically manage the problem of antimicrobial resistant bacteria as a whole were not available.

Antibiotics differ from other types of antimicrobial medicines, for instance, antiviral and antifungal medicines, because in addition to their benefits in preventing and treating naturally occurring acute illness due to bacterial infection, they are also frequently used to prevent and treat infection resulting from surgery, immunosuppression post chemotherapy and other medical procedures. In this respect, antibiotics are considered to be an instrumental pillar in the practice of modern medicine.

The scope of Thailand's National AMR Strategy 2017–2021 is also aligned with the Global Action Plan on Antimicrobial Resistance that was endorsed by Member States in the 68th World Health Assembly.

1 Antimicrobial resistance situation analysis

1.1 Situation and impact of antimicrobial resistance

The discovery of antibiotics in 1928 and their demonstrable ability to save millions of people from bacterial infections was such an important achievement for humankind that they were dubbed a ‘miracle drug’.¹ At present, however, this miraculous ability is significantly threatened by the emergence of resistant bacteria. As a result, some antibiotics that were effective in the past are now rendered ineffective. In the last 30 years, while AMR has shown an increasing trend, the number of new antibiotics released to the market has declined to the extent that from 2008–2012 only two new antibiotics were produced. However, even these antibiotics are not used for the multi-resistant gram negative bacteria that are currently posing a threat.² The problem is further compounded because the pharmaceutical industry does not consider research and development of these medicines to be a worthwhile investment given that bacteria can rapidly develop resistance. As a result, investment has shifted towards medicines used for the treatment of chronic diseases such as diabetes, hypertension and heart disease because of their enduring sales profile and market viability.³

The World Health Organization (WHO) also reports that the number of bacteria showing antimicrobial resistance continues to increase while the effectiveness of currently available antibiotics is declining. This situation, together with the lack of new alternatives means that countries around the world are at risk of entering a post-antibiotic era in which currently minor bacterial infections could become fatal. This would severely impair modern medical practice, so that important medical procedures such as appendectomy, knee replacement surgery, organ transplantation and chemotherapy – that all rely to some extent on the effectiveness of antibiotics to prevent and treat infection can no longer be undertaken.

In Thailand, nosocomial infection from resistant gram negative bacteria is a major problem, for example, infections with *Acinetobacter* spp. and *Pseudomonas*

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spp., are key causes of mortality in hospitals. In community settings, resistant *Escherichia coli* (*E. coli*), *Klebsiella* spp. and *Neisseria gonorrhoeae* (*N. gonorrhoeae*) are major threats whereas for livestock and food production, important resistant bacteria are *E. coli*, *Campylobacter* spp., and *Salmonella* spp. Importantly, treatment options are limited by AMR, especially resistance to carbapenem and colistin, which can be medicines of last resort in the treatment of infection caused by antibiotic resistant bacteria.⁴

In terms of global impact, it is estimated that approximately 700,000 people die from AMR annually. If the issue is not addressed urgently, it is expected that this figure could reach 10 million people in 2050. The greatest impact would be on Asia, with AMR mortality reaching 4.7 million people, equivalent to an economic impact of approximately THB 3,500 trillion (USD 100 trillion).⁵ For Thailand, preliminary research suggests that there are approximately 88,000 cases of antimicrobial resistant bacterial infection in humans each year, of which 38,000 cases were fatal; equivalent to an economic impact of THB 42 billion.⁶

1.2 Factors contributing to development and spread of antimicrobial resistance

The increased and inappropriate use of antimicrobial medicines in medical practice, public health, veterinary practice and agriculture plays a major role in the current epidemiology of AMR. Data from the Thai Food and Drug Administration (FDA) indicates that the level of manufacture and importation of antimicrobial medicines has been highest amongst all types of medicines since 2000. In 2009, manufacturing and importation of antibiotics amounted to THB 11 billion, higher than medicines used for treating cardiovascular diseases (THB 9.2 billion), central nervous system disorders (THB 9.0 billion) and cancer (THB 7.9 billion).⁷

Inappropriate use of antimicrobial medicines is found nationwide in all levels of healthcare facility. In university hospitals, inappropriate use of antimicrobial medi-

cines reaches 25–91%.^{8–11} Examples of inappropriate use include using antibiotics for the common cold (i.e. a viral infection); a practice which is found in public and private hospitals, as well as clinics and pharmacies. Private hospitals also tend to prescribe antibiotics for upper respiratory infections (URI) in both children and adult patients more often than is the case in public and university hospitals.¹² Information from the National Health Security Office (NHSO) suggests that in 2012 for the treatment of URI, only 3% of approximately 900 hospitals prescribe antibiotics appropriately and within the suggested standard (< 20% of all URI cases). Meanwhile, most hospitals (81%) prescribe antibiotics at a level significantly more than the defined standard (> 40%).⁴ Patients covered by the Civil Servant Medical Benefit Scheme and the Social Security System are given antibiotics more often than those under the Universal Health Coverage (UHC) scheme¹². Pharmacies also dispense antibiotics for diseases that do not require them, for instance, common cold, sinusitis and fresh, clean, minor wounds, at levels up to 64 – 80%.¹³ Although data on antibiotic use in clinics and private hospitals is limited, it can be expected that the problem is at least as serious as that found at public hospitals.

Furthermore, there is widespread use of antimicrobial medicines in situations where incorrect disposal could result in environmental impact. Inspection of still water ponds in pig farms reveals higher traces of antimicrobial resistant microbes compared to canals and shrimp and fish ponds.¹⁴ Antimicrobial medicines are also used to treat plant diseases such as citrus greening.¹⁵ At present, Thailand has limited information and has undertaken insufficient analysis of the risk or impact of widespread use of antimicrobial medicines, including information on their disposal and treatment prior to discharging related waste into the environment – an action that might result in additional impact on human and animal health.

Convenient and rapid international travel, increased international trade, promotion of medical hubs and the accelerated growth of health tourism are also factors contributing to the spread of antimicrobial resistant bacteria. For example, in 2010 resistance in *E. coli* due to the New Delhi metallo-beta-lactamase-1 (NDM-1) gene

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was found in a European having medical care abroad who became infected and returned back to their country with resistant bacteria. Subsequently, bacteria with NDM-1 spread across the world, including Thailand.¹⁶

Resistant bacteria are also known to be widespread in the agricultural sector. In November 2015, gram negative bacteria with a new resistance mechanism (plasmid-mediated colistin resistance: MCR-1), enabling easier and faster transfer of resistant genes across bacterial species was reported in farm animals in China.¹⁷ Subsequently, in December 2015 bacteria with the MRC-1 gene were also found in humans and in meat in England.¹⁸ This resistant bacteria can now be detected in a number of countries, including Thailand.¹⁹

To date, measures to tackle the problem of antimicrobial resistance are yet to be fully integrated. Neither an integrated AMR surveillance system that covers within and across healthcare facilities, nor the linkage of AMR surveillance data between humans, animals and environment have yet been established. Many healthcare facilities show limitations in addressing AMR issues and these problems are compounded by overcrowding in inpatient units of hospitals, which has led to increased risk of AMR infection and treatment failure. Furthermore, it is expected that changes in Thailand's population structure will result in much higher numbers of elderly people seeking health care with growing demand on the use of antimicrobials, at the same time as the risk of infection by resistant bacteria is expected to increase.

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The challenges posed by antimicrobial resistance need to be urgently addressed in order to prevent potentially irreversible and devastating consequences in the foreseeable future. However, the solution to the AMR challenge is complicated due to the involvement of many sectors, including human health, animal health and the environment. Therefore, AMR stakeholders are diverse and encompass the areas of medical care, public health, veterinary practice, agriculture, education, environment, civil society and all Thai citizens. It is therefore essential that there is full awareness of the AMR problem by all these parties. In addition, reducing the burden of illness and infection will require appropriate and responsible use of antimicrobials, together with measures for both prevention and health promotion. Furthermore, strengthening of the antimicrobial control and distribution system, and of AMR surveillance in humans, animals and the environment will also be critical.

2.1 Rationale

The rationale for the development of Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021 is summarized as follows.

1. There is a need to confront the serious threat that AMR poses to the country. In the past, AMR was included separately as a component in many policies, resulting in a lack of clear direction at the national level in addressing the problems it presents. Thus, there is the need for the national strategic plan to serve as the main policy guidance in addressing relevant national AMR issues. The national strategic plan will also enable the establishment of a national coordinating mechanism to address AMR issues in an effective, consolidated and sustainable manner.

2. There is a need to prevent potential negative consequences that could result from the international spread of AMR and that might affect economy, trade and

tourism. This AMR impact might be accelerated by cross-border transportation, cross-border trade and through the existence of hubs for medical care and medical tourism. These factors could potentially increase risks of AMR transmission internationally.

3. There is a need to align with efforts of other nations to confront AMR, a significant threat to global health security. This will also support the implementation of the WHA resolution on the Global Action Plan on AMR.

2.2 Chronology of Strategic Plan development

In October 2014, the Ministry of Public Health (MOPH) held a consultative meeting among various stakeholders to undertake a situation analysis on the management of AMR, and to explore options for the integration of AMR activities. The meeting concluded that despite having the systems to deal with AMR issues, the overall management of AMR was fragmented. Therefore, the development and implementation of national level AMR policy was required to reduce overlaps, lack of coordination, and other administrative issues.

However, individual stakeholders were generally found to have perspectives confined to their own area of responsibility without adequate understanding of the overall AMR situation or of actions implemented by other relevant partners. This situation was not ideal in terms of advocacy for policy at national level. Subsequently, the findings from this meeting were compiled and presented in a technical report “The Landscape of Antimicrobial Resistance Situations and Actions in Thailand.”⁴ The report aimed to be an information resource for relevant stakeholders and those who are interested in AMR problems to understand the overall AMR situation and actions undertaken by various stakeholders at national level, as well as outlining Thailand’s international role in dealing with this global health threat. The expectation was that the

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report would increase understanding among stakeholders and therefore lead to efficient coordination among concerned parties.

In May 2015, the MOPH took steps towards establishing a framework for integration of AMR work. A “Coordination and Integration Committee on Antimicrobial Resistance” was appointed, which was subsequently redefined to optimize continuity (Appendix A). The Committee consisted of representatives from the MOPH, the Ministry of Agriculture and Cooperatives (MOAC), the academic sector, professional associations, and civil society, and was tasked with the development of a National Strategic Plan on Antimicrobial Resistance 2017–2021 as a framework for stakeholders to harmonize work on AMR in Thailand.

The development of the National Strategic Plan on Antimicrobial Resistance 2017–2021 was based on a participatory process involving multi-sectoral stakeholders. The MOPH and the MOAC serve as the main coordinators bringing together all actors from other sectors to work together, including the public and private sectors, academia, professional bodies, and civil society.

The details of activities to integrate AMR activities in Thailand and of the development of Thailand's National Strategic Plan on Antimicrobial Resistance 2017–2021 are illustrated in Appendix B.

2.3 Underlying concepts and guiding principles for development of the Strategic Plan

The development of Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021 is based on two underlying concepts and three guiding principles as follows.

Underlying concepts

1. **The One Health approach** emphasizes collaboration across the human, animal and environment sectors in order to consolidate and synergize efforts and actions and to enhance the health of all living things.

2. **The triangle that moves the mountain** focuses on collaboration from all sectors (whole society engagement) which suggests that resolving a difficult and complex issue requires coordinated efforts in three areas (i.e. knowledge generation, social movement, and political/policy commitment). Knowledge generation is crucial for social movement and policy decision-making. The interface of all three elements enables change to occur in systems, social rules, laws and structures by the synergistic combination of intellectual, societal and governmental power.

Guiding principles

1. **Action-oriented strategy.** Thailand's National Strategic Plan on Antimicrobial Resistance is designed to pinpoint clear and measurable targets for relevant stakeholders to implement the plan in a stepwise manner leading to continued achievement of incremental targets for implementation.

2. **Synergized and orchestrated strategy.** This national strategic plan does not aim to regulate or replace existing policies, strategies or interventions. It aims to foster synergies of existing efforts by orchestrating and facilitating coherence of processes and actions implemented by relevant stakeholders.

3. **Political commitment stimulating strategy.** In the past, actions to resolve AMR issues have generally been handled at the technical level and received no or little attention from the political level. This situation undermines the effectiveness and continuity of actions to address AMR issues. Indeed, apart from the technical

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aspects, political commitment is a key factor leading to proper resource allocation in order to solve AMR issues effectively and sustainably.

2.4 Coherence between the National Strategic Plan on Antimicrobial Resistance and other policies

The development of Thailand's National Strategic Plan on AMR 2017-2021 recognizes, values and promotes policy coherence with other policies at national, regional and global levels to promote the effectiveness and unity of actions addressing AMR issues at all levels. Key policies are presented as follows.

1. The National Economic and Social Development Plan Vol. 12 (2017-2021) This is the main national plan that provides guidance and direction while emphasizing various critical issues, including the need to enhance arrangements for provision of healthcare for an aging society, to advance health system management to reduce inequity and promote long-term sustainability, and to strengthen national capacity to become an international hub for medical care. In this context, AMR is a significant factor that could exert a great influence on health and national development.

2. The Global Action Plan on Antimicrobial Resistance (GAP-AMR)

Developed under the tripartite of WHO/FAO/OIE, the GAP-AMR was adopted during World Health Assembly session 68th (May 2015). The GAP-AMR consists of five strategic objectives: (1) to improve awareness and understanding of antimicrobial resistance; (2) to strengthen knowledge through surveillance and research; (3) to reduce the incidence of infection; (4) to optimize the use of antimicrobial agents; and (5) to ensure sustainable investment in countering antimicrobial resistance. It has five underlying principles: (1) whole-of-society engagement including a One Health approach, (2) prevention first, (3) access, (4) sustainability, and (5) incremental targets for implementation.

3. United Nations General Assembly (UNGA). The 71st session of the UNGA (September 2016) adopted a Political Declaration of the High-Level Meeting of the General Assembly on Antimicrobial Resistance. Advocating for inclusion of AMR in a high level meeting at UNGA has been supported by many international organizations and countries, for example WHA resolution 68.7, G-7, G-77, the Alliance of Champions fighting against AMR and Global Health Security Agenda.

4. Global Health Security Health Security Agenda (GHSA). GHSA focuses on the prevention, detection and response to health emergencies that can impact on global health security. AMR is listed as a 'Prevent' action package in GHSA and Thailand provides support as a contributing country on AMR.

5. International Health Regulations 2005 (IHR 2005) The International Health Regulations requires WHO Member States to establish eight core competencies to support preparedness and response to international health emergencies. It emphasizes detecting and controlling health emergencies across borders. Implementation of IHR is considered mandatory and is guided by self-assessment through a monitoring and evaluation framework.

6. Joint External Evaluation Tool for International Health Regulation 2005²⁰ (JEE). The JEE consists of 19 priority areas, including AMR. It combines 11 action packages of GHSA and eight core competencies of IHR together. Unlike the IHR monitoring and evaluation framework, the use of the JEE involves external evaluators to support the assessment.

7. World Organisation for Animal Health (OIE). AMR is included in requirements and guidance issued by OIE, for example, the Terrestrial Animal Health

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Code, the Aquatic Animal Health Code and the Manual of Diagnostic Tests and Vaccines for Terrestrial Animals. In addition, OIE, in collaboration with FAO and WHO, has developed the OIE Global Strategy against Antimicrobial Resistance and the List of Antimicrobial Agents of Veterinary Importance. It also provides training on animal products for Member States' national focal points.

8. Food and Agriculture Organization of the United Nations (FAO) The 39th session of the FAO Assembly (June 2015) adopted a resolution on AMR with an emphasis of prudent use of antibiotics in agriculture. FAO is also a partner in setting food standards and actively supports and engages in both studying antimicrobial distribution and use in the food production chain, as well as the economic impact of limiting use of antimicrobials in agriculture and on building laboratory capacity to detect AMR, in addition to interpreting and sharing results among member states. Additionally, FAO supports collaboration among ASEAN and South Asian Association for Regional Cooperation (SAARC) countries in establishing a collaboration framework for technical capacity building, surveillance and risk management of transmissible diseases.

9. Codex Alimentarius. The Codex Alimentarius Commission (CAC) establishes a Code of Practice to minimize and contain antimicrobial resistance (CAC/RCP 61-2005) and has a Guideline for Risk Analysis of Foodborne Antimicrobial Resistance (CAC/GL 77-2011) to address food-related AMR issues that are associated with the use of antimicrobials in agriculture. Presently, the code and the guideline are being reviewed and updated. An ad-hoc working group will be established to specifically address AMR issues.

10. ASEAN post-2015 Health Development Goals. The ASEAN post-2015 Health Development Goals consist of four clusters responding to common priority

health threats posed to ASEAN countries. AMR is listed in Cluster 2 - Responding to all hazards and emerging threats.

11. Southeast Asia Region collaboration. The WHO South-East Asia Region Office (SEARO) serves as a Secretariat to facilitate collaboration of 11 Member States. The South East Asia regional commitments on addressing AMR were articulated in the Ministerial Jaipur Declaration on Antimicrobial Resistance in 2011 and in the subsequent inclusion of AMR in the Regional Director's 'flagship priorities' in 2014.

12. National Strategy on Drug System Development (2012-2016). This strategy is under the National Policy on Medicine 2011. It includes a strategy to promote rational use of medicines, which covers use and distribution of antimicrobials for human and animal use.

13. National Strategic Plan for Emerging Infectious Disease Preparedness, Prevention and Response (2017-2021). This strategy includes AMR as an issue of emerging infectious diseases. Since it can affect humans, animals and environment, the strategy highlights the need for collaboration through the One Health approach to resolve AMR problems.

14. The 6th session of National Health Assembly (NHA) (2014). The 6th NHA passed a resolution on Multidisciplinary Collaboration on Health Care for Humans, Animals and Environment towards Sustainable Well-being (One Health) to emphasize the importance of using the One Health approach to address complex issues affecting human health, animal health and the environment. It requires collaboration from a number of agencies, organizations and sectors to resolve AMR problems in a sustainable manner.

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15. The 8th session of National Health Assembly (NHA) (2015). The 8th NHA passed a resolution on the “Crisis of antimicrobial resistance and integrated problem solving”. This resolution focuses on the collaboration and integrated efforts of multiple sectors to resolve issues of bacterial resistance and the advocacy on issues related to bacterial resistance to antibacterial medicines, as part of the national agenda.

2.5 Integrated implementation of the National Strategic Plan on Antimicrobial Resistance with other related policies

Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021 emphasizes an integrated approach to working with other related policies. For example, the National Strategy on Drug System Development 2012-2016 has an action plan to promote good governance on ethical criteria for drug promotion, and to develop a curriculum for rational use of drugs, including antimicrobials in schools of medicine, dentistry, pharmacy, veterinary medicine and nursing. Thus, Thailand's National Strategic Plan on Antimicrobial Resistance will align with on-going activities implemented under other policies.

In addition, Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021 is the main national policy on addressing AMR. Thus, it can be referred to and used as an input for developing future AMR-related policies and programs in order to consolidate efforts to address AMR issues.

2.6 Strength, Weakness, Opportunity and Threat (SWOT) Analysis

The results of an analysis of strengths, weaknesses, opportunities and threats are summarized as follows.

Strength

- S1 Existence of agencies, committees and multi-sectoral partners working on addressing AMR issues
- S2 Good collaboration and partnership with civil society organizations
- S3 Availability of experts related to various aspects on AMR
- S4 Active role of the country to address AMR at regional and global levels
- S5 Using multi-sectoral and transdisciplinary interventions under the One Health approach

Weakness

- W1 Discontinuity of policy in addressing AMR issues
- W2 No clear direction and shared goals due to no national policy specifically targeting AMR
- W3 Lack of a coordinating and integrating mechanism on AMR at the national level
- W4 Ineffectiveness of law enforcement
- W5 Fragmented information and database systems
- W6 Lack of effective mechanisms to regulate use of antimicrobials in private hospitals and clinics
- W7 Architectural/Physical structure of healthcare facilities that does not accommodate the prevention and control of AMR pathogens
- W8 AMR surveillance system that has not yet been responsive in a timely manner
- W9 Lack of AMR epidemiologists
- W10 Limited number of quality microbiology laboratories
- W11 Lack of microbiology laboratories with adequate AMR knowledge

Opportunity

- O1 Positive influences from global trends in addressing AMR problems
- O2 High-level executives playing attention to AMR issues

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- O3 Availability of global policies and strategies on AMR e.g., the Global Action Plan on Antimicrobial Resistance as guidance in developing the national action plan on AMR
- O4 Availability of national policies relating to AMR such as the National Strategy on Drug System Development 2012-2016, the National Strategic Plan for Emerging Infectious Disease Preparedness, Prevention and Response 2017-2021, the 6th National Health Assembly resolution regarding One Health collaboration and the 8th NHA resolution regarding antibacterial resistance
- O5 Well-established structure of the healthcare system in Thailand

Threats

- T1 Culture and beliefs regarding antimicrobial medicines in Thai society as well as habitual practice of self-medication with antimicrobial medicines
- T2 People can access to antimicrobial medicines easily
- T3 Resistance to legislative strengthening and enforcement to control distribution of antimicrobial medicines
- T4 Intangible characteristic of AMR due to its asymptomatic feature which differs from other infectious diseases that can be detected and understood more easily
- T5 The speed of transportation and globalization increases the risks of antimicrobial resistant bacteria becoming more widespread.
- T6 Incomplete knowledge and technologies on AMR
- T7 Shortage of new antimicrobials
- T8 Use of antimicrobial medicines in agriculture
- T9 Use of antimicrobial medicines in companion animals

The results of the SWOT analysis indicated important strategic areas in which the National Strategic Plan on Antimicrobial Resistance needs to focus, as follows.

	Analysis results
1. Development of the National Strategic Plan on Antimicrobial Resistance integrating relevant actions and systems addressing AMR that are in line with global and national AMR-related policies	S 1-2; O 1-4
2. Development of a national mechanism to govern the AMR management system	O 2; W 1-3, 6
3. Strengthening international collaboration to support knowledge generation and innovation addressing AMR at national and international level	O 1-3; W 5-8
4. Ensuring sustainability of AMR management systems by integrating the systems with the healthcare system, especially in healthcare facilities	O 5; W 3-4
5. Increasing public awareness by involving and partnering with the civil society sector	S 2; T 1-2
6. Strengthening the information and database system to increase the effectiveness of law enforcement and to provide evidence for policy decision-making	W 4-5; T 2
7. Promoting research and development to address AMR issues	S 3; T 7
8. Development of surveillance systems to cover antimicrobial use and AMR in humans, animals and environment as well as to develop a warning system that can provide signals in a timely manner	W 8-11; T 4-5, 8-9

2.7 Vision, Mission and Goals

Vision

Reduction of mortality, morbidity and economic impact of AMR

Mission

Establish policies and national multi-sectoral mechanisms which support an effective and sustained AMR management system

Goals

By the year 2021

1. 50% reduction in AMR morbidity
2. 20% reduction in antimicrobial consumption in humans
3. 30% reduction in antimicrobial consumption in animals
4. 20% increase of public knowledge on AMR and awareness of appropriate use of antimicrobials
5. Capacity of the national AMR management system is improved to level 4¹

¹¹ This is measured by the WHO's Joint External Evaluation Tool (JEE) for International Health Regulations (2005).

2.8 Strategy and Strategic action

The National Strategic Plan on Antimicrobial Resistance 2017-2021 consists of six strategies and 22 strategic actions.

Strategy 1 AMR surveillance system using the One Health approach

Strategic objective : The AMR surveillance system is capable of indicating problems as well as monitoring and reporting the AMR epidemiological situation in both humans and animals in order to provide timely alerts on AMR spread.

Strategic action 1.1 Strengthen the national integrated system of AMR surveillance and signaling

Strategic action 1.2 Strengthen capability and networking of microbiology laboratories

Strategic action 1.3 Improve epidemiological capacity and networking on AMR

Strategy 2 Regulation of antimicrobial distribution

Strategic objective: The systems of controlling and tracing distribution of human and veterinary antimicrobial medicines are integrated.

Strategic action 2.1 Strengthen the antimicrobial distribution control system for both humans and animals

Strategic action 2.2 Enhance efficient law enforcement in conjunction with use of social measures to mitigate the problem of inappropriate distribution of antimicrobials

2. Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021

Strategy 3 Infection prevention and control and antimicrobial stewardship in humans

Strategic objectives: Healthcare facilities are equipped with efficient systems to prevent and control infection aiming at reducing infection rate and expenses caused by AMR pathogens and to implement antimicrobial stewardship.

Strategic action 3.1 Address AMR problems in both public and private healthcare facilities in a systematic and integrated manner

Strategic action 3.2 Strengthen competency of infection control personnel

Strategic action 3.3 Implement, monitor and evaluate antimicrobial stewardship in healthcare facilities

Strategic action 3.4 Implement antimicrobial stewardship in private clinics

Strategic action 3.5 Implement antimicrobial stewardship in pharmacies

Strategy 4 AMR prevention and control and antimicrobial stewardship in agriculture and animals

Strategic objective: Integrated and harmonized systems of AMR management and reduction of antimicrobial use in agricultural and animal sectors are applied to both public and private sectors.

Strategic action 4.1 Reduce use of antimicrobials in livestock farming and fisheries

Strategic action 4.2 Reduce antimicrobial resistant bacteria in the food production chain

- Strategic action 4.3 Establish surveillance of antimicrobial use in crop production
- Strategic action 4.4 Implement antimicrobial stewardship in animal hospitals and clinics
- Strategic action 4.5 Educate relevant stakeholders in food animals and agriculture regarding appropriate use of antimicrobials

Strategy 5 Public knowledge on AMR and awareness of appropriate use of antimicrobials

Strategic objective : The public are knowledgeable of AMR and aware of appropriate antimicrobial use, including environmental contamination of AMR organisms.

- Strategic action 5.1 Support roles of civil society and mass media agencies to increase public understanding of AMR and appropriate use of antimicrobials
- Strategic action 5.2 Improve health literacy on AMR and awareness of appropriate use of antimicrobials for the public especially in children, adolescent and working age groups
- Strategic action 5.3 Empower and reinforce participatory engagement of communities and lay people networks

Strategy 6 Governance mechanisms to move AMR policy and actions forward in a sustainable manner

Strategic objective: AMR implementation mechanisms at national level are able to sustain AMR-related actions







- Strategic action 6.1 Establish national level structure and mechanism to move the strategic plan and AMR operations forward

2. Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021

- Strategic action 6.2 Administer, monitor and evaluate the implementation of the strategic plan
- Strategic action 6.3 Support research and development to guide efficient AMR operations
- Strategic action 6.4 Sustain Thailand's proactive and collaborative role in AMR at international level

Note: A list of major antimicrobial resistant bacteria and major antibiotics is indicated in Appendix C.

2.9 Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021

Vision: Reduction of mortality, morbidity and economic impacts from AMR					
Mission: Establish policies and national multi-sectoral mechanisms which support an effective and sustained AMR management system					
Goals: By the year 2021 <div> 1. 50% reduction in AMR morbidity 2. 20% reduction in antimicrobial consumption in humans 3. 30% reduction in antimicrobial consumption in animals 4. 20% increase of public knowledge on AMR and awareness of appropriate use of antimicrobials 5. Capacity of the national AMR management system is improved to level 4 </div>					
<div>      </div>					
	Strategy 1 AMR surveillance system using One Health approach	Strategy 2 Regulation of antimicrobial distribution	Strategy 3 Infection prevention and control and antimicrobial stewardship in humans	Strategy 4 AMR prevention and control and antimicrobial stewardship in agriculture and animals	Strategy 5 Public knowledge on AMR and awareness of appropriate use of antimicrobials
Strategic objective	The AMR surveillance system is capable of indicating problems as well as monitoring and reporting the AMR epidemiological situation in both humans and animals in order to provide timely alerts on AMR spread.	The systems of controlling and tracing distribution of human and veterinary antimicrobial medicines are integrated.	Healthcare facilities are equipped with efficient systems to prevent and control infection aiming at reducing infection rate and expenses caused by AMR pathogens, and to implement antimicrobial stewardship.	Integrated and harmonized systems of AMR management and reduction of antimicrobial use in agricultural and animal sectors are applied to both public and private sectors.	The public are knowledgeable of AMR and aware of appropriate antimicrobial use, including AMR environmental problems.
Strategic action	1.1 Develop the national integrated system of AMR surveillance and signaling 1.2 Strengthen capacity and networking of microbiology laboratories 1.3 Improve epidemiological capacity and networking on AMR	2.1 Strengthen the antimicrobial distribution control system for both humans and animals, 2.2 Enhance efficient law enforcement in conjunction with use of social measures to mitigate the problem of inappropriate distribution of antimicrobials	3.1 Address AMR problems in both public and private healthcare facilities in a systematic and integrated manner 3.2 Strengthen competency of infection control personnel 3.3 Implement, monitor and evaluate antimicrobial stewardship in healthcare facilities 3.4 Implement antimicrobial stewardship in private clinics 3.5 Implement antimicrobial stewardship in pharmacies	4.1 Reduce use of antimicrobials in livestock farming and fisheries 4.2 Reduce antimicrobial resistant bacteria in the food production chain 4.3 Establish surveillance of antimicrobial use in crop production 4.4 Implement antimicrobial stewardship in animal hospitals and clinics 4.5 Educate relevant stakeholders in food animals and agriculture regarding appropriate use of antimicrobials	5.1 Support roles of civil society and mass media agencies to increase public understanding of AMR and appropriate use of antimicrobials 5.2 Improve health literacy on AMR and awareness of appropriate use of antimicrobials for the public especially in children, adolescent and working age groups 5.3 Empower and reinforce participatory engagement of communities and lay people networks
<div>  </div>					
Strategy 6 Governance mechanisms to move AMR policy and actions forward in a sustainable manner					
Strategic objective AMR implementation mechanisms at national level are able to sustain AMR-related actions					
Strategic action 6.1 Establish national level structure and mechanism to move the strategic plan and AMR operations forward 6.2 Administer, monitor and evaluate the implementation of the strategic plan 6.3 Support research and development to guide efficient AMR operations 6.4 Sustain Thailand's proactive and collaborative role in AMR at international level					

3

Monitoring and Evaluation

3.1 Monitoring and evaluation concept

The monitoring and evaluation of the implementation of Thailand's National Strategic Plan on Antimicrobial Resistance 2017–2021 uses the developmental evaluation approach²¹ to improve and adapt the working processes used to support the implementation of the strategy. The developmental evaluation approach acknowledges and is responsive to complexities of systems including the uncertainties of situational and environmental changes that may affect the implementation processes. Guided by evidence provided by the monitoring and evaluation process, it is expected to increase the likelihood of an effective implementation of Thailand's National Strategic Plan on Antimicrobial Resistance 2017–2021.

3.2 Monitoring and evaluation framework

The framework to monitor and evaluate the five-year goals of Thailand's National Strategy on Antimicrobial Resistance 2017–2021 is as follows.

Goal 1: 50% reduction in AMR morbidity

Bacteremia caused by five resistant bacterial pathogens, i.e., *Acinetobacter* spp., *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae* and *Pseudomonas* spp. in large hospitals located in five regions (North, South, Northeast, East and Central regions) and one from Bangkok will be used as a surrogate marker to assess AMR morbidity. The baseline data will be derived from the retrospective data of the years 2012–2016 of each target hospital. A 50% reduction is both the goal of each hospital and the national overall goal. Reporting is indicated in Appendix D.

Goal 2: 20% reduction in antimicrobial consumption in humans

The measurement of antimicrobial consumption in humans will be retrieved from the national databases of annual reports of pharmaceutical production and importation. Pharmaceutical companies are required by law to report these data to the Food and Drug Administration. Antimicrobial consumption will be calculated in a unit of Defined Daily Dose (DDD) per 1000 inhabitant day. The future levels of antimicrobial

3. Monitoring and Evaluation

consumption will be compared with the past three years of baseline data on antimicrobial consumption to monitor changes of antimicrobial consumption resulting from implementation of Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021.²²

Goal 3: 30% reduction in antimicrobial consumption in animals

The national databases of annual reports of veterinary medicine production and importation that pharmaceutical companies report to the Food and Drug Administration will be the main source of data for the assessment of antimicrobials used in animal. The amount of antibiotic used is calculated in terms of kilogram of active ingredient per Population Correction Unit (PCU), the calculation would be in comparison with the amount used in animals in the past three years.²²

Goal 4: 20% increase of public knowledge on AMR and awareness of appropriate use of antimicrobials

A questionnaire together with an interview among the targeted population will be conducted every two years to assess public knowledge on AMR and awareness of the appropriate use of antimicrobials. In 2017, the first survey will be conducted to establish the baseline data and the subsequent surveys in 2019 and 2021 will be conducted to measure changes after the implementation of Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021 commences, with the five-year goal of a 20% increase of public knowledge on AMR and awareness of the appropriate use of antimicrobials.

Goal 5: Capacity of the national AMR management system is improved to level 4

Thailand's AMR management system would be compared with WHO international standards in relation to two main tools as follows:

(1) The Joint External Evaluation Tool for the International Health Regulations (2005)²⁰. This tool serves as implementation guidance to address AMR in both humans and animals, including in the agricultural sector. The tool employs four indicators (1) Detection of antimicrobial resistant bacteria by designated laboratories (2) Surveillance of infections caused by AMR pathogens at designated sentinel sites (3) Healthcare associated infection prevention and control programs at designated facilities (4) Antimicrobial stewardship activities at designated centers. Each indicator has five scores/levels. The overall scores are shown below.

Scores (Levels)	Criteria*
1	No national plans addressing each of four dimensions on AMR
2	Approval of the national plans addressing each of four dimensions of AMR
3	Implementation of some aspects of the national plans in designated laboratories, facilities, centers or sentinel sites
4	Continuing implementation of all aspects of the national plans (level 3) for at least one year
5	Continuing implementation of all aspects of the national plans (level 4) for at least five years with a system for continuous improvement

Note: *These contents are modified from Joint external evaluation tool for the International Health Regulations (2005)²⁰

3. Monitoring and Evaluation

(2) The monitoring and evaluation framework of the Global Action Plan on Antimicrobial Resistance. This framework, which is being developed by WHO would also guide evaluation of the strategic plan implementation.

In conclusion, the monitoring and evaluation framework of the National Strategic Plan on Antimicrobial Resistance 2017-2021 is shown below.

Indicators	Baseline data in 2016	Targets by year					Method/ source of information
		2017	2018	2019 (cumulative number)	2020 (cumulative number)	2021 (cumulative number)	
1. Reduction of morbidity caused by AMR (percent)	NA	Baseline data available	10	20	35	50	Survey
2. Reduction of antimicrobial consumption in humans (percent)	NA	Baseline data available	5	10	15	20	Annual report on drug production and importation
3. Reduction of antimicrobial consumption in animals (percent)	NA	Baseline data available	10	15	20	30	Annual report on drug production and importation
4. Increased public knowledge on AMR and awareness of appropriate use of antimicrobials (percent)	NA	Baseline data available	NA	10	NA	20	Biennial survey
5. National AMR management system achieves international standard capacity level 4 (level of success)	1*	2 for some dimensions	2 for all dimensions	3 for some dimensions	3 for all dimensions	4	WHO's M&E framework and JEE

* A self-assessment in 2016 using the JEE to assess the current Thailand AMR management system indicated a score of 1 due to the fact that although Thailand has many interventions addressing AMR in various levels and dimensions, it did not have national plans to explicitly address AMR in each dimension and to determine designated or sentinel sites for implementation and evaluation.

4

Expected
results

4. Expected results

The expected results from implementing the National Strategic Plan on Antimicrobial Resistance 2017-2021 are divided into two phases as follows.

4.1 Short-term achievement

The short-term achievements are categorized into three periods: three, six and 12 months. They consist of eight items as follows.

By three months

1. Establishment of National Committee on Antimicrobial Resistance

This National Committee serves as a fundamental platform and a national mechanism to set policies, establish governance mechanisms, control, accelerate and support the implementation of Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021, as well as to monitor progress of its implementation by relevant multi-sectoral partners. The Prime Minister or designated Deputy Prime Minister will serve as the Chair of the Committee. The Committee will be multi-sectoral as it will consist of multi-sectoral partners from relevant agencies, units and organizations.

2. Establishment of national policy on promoting rational drug use in hospitals, that integrates appropriate use of antimicrobials

Inappropriate use of antimicrobials not only leads to negative effects on patient health and overall health costs, but also leads to antimicrobial resistance, with serious negative societal impacts. Unfortunately, inappropriate use of antimicrobials occurs at all levels of healthcare in both public and private settings (see Chapter 1 for details). Thus, it is essential that the policy on promoting rational drug use in hospitals needs to include antimicrobials and should initially focus on hospitals under the purview of the Ministry of Public Health.

By six months

3. Promulgation of a legislative order on withdrawal of antimicrobials from a household remedy list

In the past, access to healthcare services was difficult and therefore antimicrobials for topical use e.g., eye preparations were listed in the category of household remedies (comparable to over-the-counter drugs). However, improvement of healthcare systems, including the implementation of universal health coverage means that people are now able to access services in a timely manner. For this reason, all antimicrobials should be withdrawn from the household remedy list. This regulatory update will also strengthen the regulatory system for the control of antimicrobial distribution and enable safer use of medicines among the public.

By twelve months

4. An initiative on the integrated AMR surveillance system at least in two hospitals

The integrated AMR surveillance system will initially be implemented in a minimum of two hospitals. This system and its pilot sites will be very important for the effective control of AMR as they can indicate incidence of infections, patients at risk, and sources of AMR (whether they are healthcare-associated or community-acquired infection). Additionally, they can detect new resistant pathogens, prevent them from spreading widely and support a timely response. The integrated AMR surveillance system will also lead to the development of alert and coordinating systems across agencies at local and national levels. In the past, lack of an integrated AMR surveillance system impeded the effective control of important resistant pathogens. An example is the case of NDM-1-producing *E. coli* that was first detected in a hospital in the northeast region of Thailand. Unfortunately, due to the absence of an integrated AMR surveillance system, this highly resistant pathogen is now found in many hospitals across the country, resulting in impacts on patient health as well as budgetary burdens associated with its treatment.

4. Expected results

5. An initiative to establish an integrated system for AMR management in 24 provincial and regional hospitals in 12 area health systems

An integrated system for AMR management will consist of two parts: (1) strengthening the existing measures and systems in the hospitals i.e., the AMR surveillance system, the microbiology laboratory system, the infection prevention and control system and the promotion of appropriate use of antimicrobials; and (2) developing and implementing proactive measures and systems, i.e., referral systems for patients infected by resistant microbes, mortuary management relating to AMR, and the interconnection of AMR alert systems ranging from provincial level to regional health system and national levels. The integrated system of AMR management emphasizes coordinated efforts across a continuum of care in order to increase the effectiveness and capacity of hospital AMR management systems that could lead to lower AMR-related morbidity, mortality and economic impacts.

6. Promulgation of a legislative order on antimicrobial reclassification

Although in some countries especially those that are more developed – all antimicrobials are regulated as prescription drugs, such regulatory measures may not currently be applicable for other countries, including Thailand, where the national context is very different. However, in order to respond to an increase in the importance of AMR, it is highly beneficial to promulgate regulations that address antimicrobial reclassification, as well as the control of distribution channels and conditions for these drugs. Specifically, critically important antimicrobials including those at high risk of developing resistance should be regulated more restrictively than those with lower risks. The regulation on reclassification of antimicrobials will take into account technical issues as well as factors associated with access to medicines and health care services.

7. Promulgation of a Ministry of Agriculture and Cooperatives Ministerial Order on regulation of the production, sales, and use of medicated feed

Drugs, including antibiotics, are after mixed into feed referred to as “medicated feed”. This form of use is regulated by two overlapping laws, the Drug Act,

for which the regulatory agency is the Food and Drug Administration under the Ministry of Public Health; and the Animal Feed Quality Control Act, for which the authority is the Ministry of Agriculture and Cooperatives. In order to avoid the overlap and potential confusion for law enforcement agencies, the Drug law will waive medicated feed as a drug from the Drug Act. Meanwhile, medicated feed will be regulated under the Animal Feed Quality Control Act. According to this law, only veterinary drugs that are registered as medicated premix are allowed in the manufacture of medicated feed, which must also be administered under the supervision of veterinarians in accordance with international standards in order to minimize risks of antimicrobial resistance and the presence of antimicrobial residues.

8. An initiative on antimicrobial stewardship in two animal hospitals

Companion animals e.g., dogs and cats are very close to humans. Inappropriate use of antimicrobials in companion animals may lead to AMR, with subsequent spread to human. Thus, in alignment with the One Health approach, it is essential to address AMR in every sector, including in relation to companion animals. This initiative is a starting point to develop a system to promote antimicrobial stewardship in animal hospitals in order to prevent and control AMR in humans and animals simultaneously.

4.2 Overall achievement

Successful implementation of Thailand's Strategic Plan on Antimicrobial Resistance 2017-2021 will be measured by two achievements, i.e., achievement of the defined goals of the strategic plan, and also through achievement of the anticipated positive impacts that would be the result.

4.2.1. Achievement of the goals

Implementation of the National Strategic Plan on Antimicrobial Resistance 2017-2021 would lead to five achievements (1) 50% reduction of AMR morbidity (2) 20% reduction of antimicrobial consumption in humans (3) 30% reduction of antimicrobial consumption in animals (4) 20% increase in public

4. Expected results

knowledge on AMR and awareness of appropriate use of antimicrobials, and (5) improvement of the capacity of the national AMR management system to level 4 (see details in Chapter 3)

4.2.2 Achievement of the expected positive impacts

The implementation of Thailand's Strategic Plan on Antimicrobial Resistance 2017-2021 is expected to gain positive impacts on people, the country and the world as follows:

4.2.2.1 Better health and safety for the public

The implementation of the National Strategic plan on Antimicrobial Resistance 2017-2021 can be expected to reduce the risk of infection and death caused by antimicrobial resistant bacteria. Reduced use of antibiotics in humans and in animals will also likely delay, stabilize or even decrease antimicrobial resistance. In addition, it could reduce the risk of allergic reactions to antimicrobials, which are occasionally fatal. The Food and Drug Administration's 30 year (1984-2014) report indicates that antimicrobials, especially antibiotics, caused the highest level of adverse drug reactions when compared with other drug groups. Analyzing only the most severe adverse drug reactions – Stevens-Johnson syndrome and toxic epidermal necrolysis – it was found that six out of 20 drugs that caused these severe reactions were antimicrobials.

4.2.2.2. Compliance with the country's vision 'stability, prosperity and sustainability'.

Achievement of the country's vision will rely on a number of factors. In this context; AMR is a significant issue with potential to seriously impact national development. Similarly, the decision of WHO to prioritize AMR is in part due to the threat it poses to global health security. The escalating AMR problem could lead the world into a post-antibiotic era, resulting in enormous loss of life as well as economic disruption. The economic cost of AMR in Thailand is estimated to be as high as 42 billion baht in 2010. It is also quite possible that without appropriate interventions, the loss would be much greater after 2024 when the country is expected

to undergo a significant demographic shift, with a much bigger elderly population and an associated increased need for healthcare services. A possible scenario is thus, 1) increased use of antimicrobials leads to increased risk of antimicrobial resistant bacterial infection, 2) national expenditure on healthcare climbs sharply due to increasingly expensive AMR treatment, and 3) at the same time, the proportion of population who work and pay taxes continuously decreases. Such a situation could easily impact national economic security and development. Therefore, the successful implementation of Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021 may be expected to help to 'stabilise' health and public health, increase 'prosperity' by reducing healthcare expenditure associated with AMR, thus 'sustaining' national development.

4.2.2.3 Thailand's international commitment and responsibility on AMR problem solving.

AMR is a problem that transcends multiple borders, including those between countries, as well as the barriers among humans, animals and the environment. Addressing the AMR problem therefore needs international collaboration. At the global level, two important programs that aim to address the AMR problem are research and development for new antimicrobials, and antimicrobial stewardship. Developed countries, many of which have capacity to produce new pharmaceuticals as well as robust AMR management systems, frequently have a focus on research and development of new antimicrobials. In contrast, developing countries like Thailand, without such strong platforms, focus instead on an approach that includes monitoring appropriate use – aiming to prolong the effectiveness of currently available and newly introduced antimicrobials. This perspective illustrates Thailand's responsibility in the international arena. As a result, the implementation of Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021 should not only help to solve the country's problems but also show the country's commitment in alignment with the Global Action Plan on AMR.

Appendices

Appendix A The Coordination and Integration Committee on Antimicrobial Resistance

Ministry of Public Health Ministerial Order

No. 727/2015

Subject: Appointment of the Coordination and Integration Committee on Antimicrobial Resistance

Antimicrobial resistance is one of the most serious health threats in the 21st century. It is also a serious global health threat that affects humans, animals, environment as well as health and economic systems at the national and global levels. Addressing this threat requires multi-sectoral collaboration. In order to ensure unity, effectiveness and continuity in addressing antimicrobial resistance at the national level, the Minister of Public Health, therefore, issues the order as follows:

1. appoint the Coordination and Integration Committee on Antimicrobial Resistance
2. task the Committee to have its components and authorities as follows

Components

1. Deputy Permanent-Secretary (Mr. Suriya Wongkongkathep)	Chair
2. Inspector-General Region 3 (Mr. Sukhum Karnchanapimai)	Deputy chair
3. Deputy Secretary-General, Food and Drug Administration (Mr. Pathom Sawanpanyalert)	Deputy chair
4. President, Veterinary Council (or designated alternate)	Committee
5. Director, Bureau of Inspection and Evaluation of the Permanent Secretary Committee Office (or designated alternate)	Committee
6. Director, Bureau of Health Administration of the Permanent Secretary Office (or designated alternate)	Committee
7. Director, Bureau of Sanatorium and Healing Arts, Department of Health Service Support (or designated alternate)	Committee
8. Director, Bureau of Epidemiology, Department of Disease Control (or designated alternate)	Committee
9. Director, Healthcare Accreditation Institute (Public Organization) (or designated alternate)	Committee
10. Director, Health Systems Research Institute (or designated alternate)	Committee
11. Director, International Health Policy Program (or designated alternate)	Committee

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12. Chair, Sub-Committee of System Development on Containment and Prevention of Antimicrobial Resistance (Mr. Visanu Thamlikitkul) (or designated alternate)	Committee
13. Chair, Sub-Committee of Practice Guideline Development for Nosocomial Infection Prevention and Control (Mr. Kumthorn Malathum) (or designated alternate)	Committee
14. Chair, Sub-Committee of Rational Drug Use (Dean of Faculty of Medicine, Siriraj Hospital, Mahidol University) (or designated alternate)	Committee
15. Manager, Drug System Monitoring and Development Center, Thai Health Promotion Foundation (or designated alternate)	Committee
16. Designated alternate, Sub-executive Committee on Antimicrobial Resistance Surveillance and Control	Committee
17. Designated alternate, Technical Committee on Medical Services for Emerging Infectious Diseases	Committee
18. Designated alternate, Technical Committee on Nosocomial Infection	Committee
19. Designated alternate, Committee of AMR Control, Prevention and Problem Solving in Animals	Committee
20. Designated alternate, Committee of AMR Control, Prevention and Problem Solving in Fisheries	Committee
21. Designated alternate, Sub-committee on AMR Prevention, Containment and Problem Solving in Humans	Committee
22. Designated alternate, Sub-committee on System Development for Surveillance and Containment of Nosocomial Infection	Committee
23. Designated alternate, Sub-committee on Human Resources for Nosocomial Infection Prevention and Control	Committee
24. Designated alternate, National Health Security Office	Committee
25. Mr. Kittit Pitaknitinan	Committee
26. Mr. Pisonthi Chongtrakul	Committee
27. Director, Bureau of Drug Control, Food and Drug Administration	Committee and Secretary
28. Ms. Nithima Sumpradit	Committee and Deputy-secretary
29. Ms. Noppavan Janejai	Committee and Deputy-secretary
30. Ms. Nopparat Mongkalagoon	Committee and Deputy-secretary
31. Designated alternate, Department of Medical Services	Committee and Deputy-secretary
32. Ms. Sitanun Poonpolsub	Committee and Deputy-secretary

The Committee' tasks and responsibilities:

1. Set national policy directions, strategic plan and operational plan on antimicrobial resistance
2. Coordinate and integrate AMR actions across sectors, link domestic and international collaborations and convene conferences or seminars regarding AMR policies domestically and internationally
3. Coordinate with related committees, sub-committees, working groups, and involved agencies, and invite experts to provide technical input and support
4. Appoint sub-committees and working groups accordingly
5. Complete the report 'Landscape of AMR situation and actions in Thailand'
6. Implement and support activities designated by the Ministry of Public Health

Effective from this point in time.

Issued on 6 May, 2015.

Professor Rajata Rajatanavin
Minister of Public Health

Appendix A

Ministry of Public Health Ministerial Order

No. 91 /2016

Subject: Appointment of the Coordination and Integration Committee on Antimicrobial Resistance

Antimicrobial resistance is a serious threat to health that affects humans, animals and the environment. Addressing this threat requires multi-sectoral collaboration, therefore, the Ministry of Public Health has issued ministerial order No. 727/2015, dated 6 May 2015, appointing the Coordination and Integration Committee on Antimicrobial Resistance.

In order to ensure unity, effectiveness and continuity in addressing antimicrobial resistance at the national level, the Minister of Public Health, by virtue of section 20, the Government Administration Act B.E. 2534 and its amendment (vol 5) B.E. 2545 issues the order as follows:

1. revoke the Ministry of Public Health Ministerial Order No. 727/2015 dated 6 May 2015
2. appoint the Coordination and Integration Committee on Antimicrobial Resistance, which consists of components and authorities as follows

Components

1. Mr. Suriya Wongkongkathep	Consultant
2. Deputy Permanent-Secretary (Health Services Support)	Chair
3. Inspector-General Region 3 (Mr. Sukhum Karnchanapimai)	Deputy chair
4. Deputy Secretary-General, Food and Drug Administration designated by the Secretary-General of the Food and Drug Administration	Deputy chair
5. Director-General, Department of Medical Services (or designated alternate)	Committee
6. Director-General, Department of Health Service Support (or designated alternate)	Committee
7. Director-General, Department of Agriculture Extension (or designated alternate)	Committee
8. Director-General, Department of Agriculture (or designated alternate)	Committee
9. Secretary-General, National Health Security Office (or designated alternate)	Committee
10. Secretary-General, National Bureau of Agricultural Commodity and Food Standards (or designated alternate)	Committee
11. Director, Bureau of Inspection and Evaluation of the Permanent Secretary Office (or designated alternate)	Committee
12. Director, Bureau of Health Administration of the Permanent Secretary Office (or designated alternate)	Committee
13. Director, Bureau of Emerging Infectious Diseases, Department of Diseases Control (or designated alternate)	Committee

14. Director, National Institute of Health, Department of Medical Sciences (or designated alternate)	Committee
15. Director, Bureau of Quality and Safety of Food, Department of Medical Sciences (or designated alternate)	Committee
16. Director, Bureau of Food Control, Food and Drug Administration (or designated alternate)	Committee
17. Director, Center of Food-borne AMR Monitoring Faculty of Veterinary Science, Chulalongkorn University (or designated alternate)	Committee
18. Director, Healthcare Accreditation Institute (Public Organization) (or designated alternate)	Committee
19. Director, Health Systems Research Institute (or designated alternate)	Committee
20. President, Veterinary Council (or designated alternate)	Committee
21. President, Community Pharmacy Association (Thailand) (or designated alternate)	Committee
22. Chair, the Committee of AMR Surveillance and Control (or designated alternate)	Committee
23. Chair, the Committee of AMR Control, Prevention and Problem Solving in Animal (or designated alternate)	Committee
24. Chair, the Committee of AMR Control, Prevention and Problem Solving in Fisheries (or designated alternate)	Committee
25. Chair, the Sub-Committee of System Development on Nosocomial Infection Surveillance and Control (or designated alternate)	Committee
26. Chair, the Sub-Committee of Practice Guideline Development for Nosocomial Infection Prevention and Control (or designated alternate)	Committee
27. Manager, Drug System Monitoring and Development Center, Thai Health Promotion Foundation (or designated alternate)	Committee
28. Ms. Boonmee Sathapatayavong	Committee
29. Mr. Visanu Thamlikitkul	Committee
30. Mr. Parntep Ratanakorn	Committee
31. Mr. Pisonthi Chongtrakul	Committee
32. Ms. Kanchana Kachintorn	Committee
33. Mr. Preecha Montakantikul	Committee
34. Mr. Pitak Santanirand	Committee
35. Director, Bureau of Drug Control, Food and Drug Administration	Committee and Secretary
36. Ms. Nithima Sumpradit	Committee and Deputy-secretary

Appendix A

37. Ms. Noppavan Janejai	Committee and Deputy-secretary
38. Designated alternate from the Bureau of Health Administration of the Permanent Secretary Office	Committee and Deputy-secretary
39. Designated alternate from the Department of Livestock Development	Committee and Deputy-secretary
40. Designated alternate from the Department of Fisheries	Committee and Deputy-secretary
41. Ms. Sitanun Poonpolsub	Committee and Deputy-secretary

The Committee's tasks and responsibilities:

1. Set policy directions and advocate AMR toward a national agenda
 2. Develop the National Strategic Plan on Antimicrobial Resistance
 3. Complete the report "Landscape of AMR situation and actions in Thailand"
 4. Coordinate with related committees, sub-committees, working groups, and involved agencies, and invite experts to provide technical input and support
 5. Appoint sub-committees and working groups accordingly
 6. Implement and support activities designated by the Ministry of Public Health
- Effective from this point in time.

Issued on 18 January, 2016.

Mr. Piyasakol Sakolsatayadorn
Minister of Public Health

Appendix B: Chronology of integration of AMR actions and the development of
Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021

Timeframe	Activities
October 2014	The MOPH held a consultative meeting among AMR stakeholders on 8 October 2014 to share information and review national AMR management. The results indicated a solid foundation for AMR-related activities, but a lack of coordination and strategic direction. This was likely due to the absence of any specific national policy on AMR. A report 'The Landscape of AMR situation and actions in Thailand' was produced and disseminated to be a common source of information for AMR stakeholders.
December 2014 – January 2015	Meetings held with representatives of MOPH and MOAC to explore mechanisms for collaboration and work integration.
February 2015	The monthly MOPH high-level meeting 2/2015 on 5 February 2015 approved a framework on national AMR integration and agreed to establish a committee responsible for this task.
May 2015	<p>The MOPH issued Ministerial Order 727/2015 on 6 May 2015 appointing 'The Coordination and Integration Committee on Antimicrobial Resistance'. The Committee was assigned to develop a national AMR strategy.</p> <p>The 68th WHA (18-26 May 2015) endorsed the Global Action Plan on Antimicrobial Resistance (GAP-AMR) and requested member countries to develop their own National Action Plan on AMR in compliance with the GAP-AMR within two years (by May 2017).</p>
June -July 2015	The Coordination and Integration Committee on Antimicrobial Resistance held its first meeting (1/2015) on 23 June 2015. The Committee endorsed that the Thailand AMR Strategic Plan would cover three years (2016-2018), established the underlying principles for the Plan and assigned coordinating agencies in each strategy.
August 2015	<p>The Project 'Development of Thailand AMR Strategic Plan' was funded by WHO.</p> <p>A workshop was held during 18-19 August 2015 to brainstorm on the AMR strategic plan. More than 120 stakeholders joined, including</p>

Appendix B

Timeframe	Activities
	<p>representatives from the areas of human health, animal health, agriculture and environment, and from all involved sectors including public, private, academic, professional bodies and civil society.</p> <p>The Coordination and Integration Committee on Antimicrobial Resistance held its second meeting (2/2015) on 24 August 2015. The Committee approved the formation of drafting groups for each strategy of the Strategic Plan.</p>
September-November 2015	The drafting groups met more than 10 times to elaborate the draft Strategic Plan. The meetings sought input from all involved sectors: including public, private, academic, professional bodies and civil society.
December 2015	<p>The 8th National Health Assembly endorsed “the 8th NHA Resolution 5: the AMR crisis and it’s integrated management”. During the Assembly there were public hearings where issues related to the AMR Strategic Plan Framework were discussed.</p> <p>The report “The Landscape of AMR situation and actions in Thailand” was completed.</p>
January 2016	Due to changes in high level positions, the MOPH Ministerial Order 91/2016 was issued on 18 January 2016 to revise the components of the Coordination and Integration Committee on Antimicrobial Resistance. The new Committee continued the development of Thailand’s Strategic Plan on Antimicrobial Resistance until completion.
February 2016	The Coordination and Integration Committee on Antimicrobial Resistance held its third meeting on 18 February 2016 to review the Draft Strategic Plan 2016-2018 and establish guidelines for a public hearing. It was agreed that both MOPH and MOAC would jointly propose the Plan to the Cabinet.
April-May 2016	A public hearing on the draft Strategic Plan was conducted between 22 April and 20 May 2016. The hearing forum was held on 22 April 2016. It was supported by the National Health Commission Office (NHCO) with

Timeframe	Activities
June 2016	<p>cooperation of eight organizations namely MOPH, MOAC, NHCO, the Thai Health Promotion Foundation, the International Health Policy Program, WHO and FAO. Approximately, 200 participants participated in the hearing forum and they were representatives from all sectors.</p> <p>The public hearing was also facilitated by circulation of the document to various agencies.</p> <p>The MOPH ministerial meeting 6/2016 on 1 June 2016 approved the extension of the Plan from three years (2016-2018) to five years (2017-2021) according the proposal from the public hearing.</p> <p>Four drafting group meetings were held and inputs from public hearings were also considered.</p> <p>The Coordination and Integration Committee on Antimicrobial Resistance held its fourth meeting, 2/2016 on 21 June 2016. The draft Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021 was approved to submit to the Cabinet.</p>
August 2016	<p>Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021 was endorsed by the Cabinet on 17 August 2016.</p>

Appendix C

Appendix C: Examples of major resistant bacteria and antimicrobials

Examples of major resistant bacteria

Major AMR bacteria	human	Food animals	Meat
<i>Acinetobacter baumannii</i> – Carbapenem – Colistin	✓ ✓		
<i>Pseudomonas aeruginosa</i> – Carbapenem – Colistin	✓ ✓		
<i>Neisseria gonorrhoeae</i> – Cefixime	✓		
<i>Klebsiella pneumoniae</i> – Colistin – Carbapenem – 3 rd Generation Cephalosporin (ESBL)	✓ ✓ ✓		
<i>Enterococcus</i> – Vancomycin (VRE)	✓		
<i>Staphylococcus aureus</i> – Methicillin (MRSA) – Vancomycin	✓ ✓		
<i>S. pneumoniae</i> – Penicillin – Ceftriaxone or Cefotaxime	✓ ✓		
<i>Escherichia coli</i> – Colistin – Carbapenem – Fluoroquinolone – 3 rd Generation Cephalosporin (ESBL)	✓ ✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓
<i>Salmonella</i> spp. – Colistin – Fluoroquinolone – 3 rd Generation Cephalosporin (ESBL)	✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓

Note: WHO highlights seven antimicrobial resistant bacteria are *E. coli*, *K. pneumoniae*, *S. aureus*, *S. pneumoniae*, *Salmonella* spp. *Shigella* spp. and *N. gonorrhoeae*.²³

Examples of major antimicrobials

Drug group	Drug items
Polymyxins	Colistin
Carbapenems	Doripenem, Ertapenem, Imipenem and Meropenem
3 rd Generation Cephalosporins	Ceftriaxone, Cefixime, Ceftazidime and Cefotaxime
Fluoroquinolones	Ciprofloxacin, Norfloxacin, Ofloxacin and Levofloxacin
Beta-lactamase inhibitor combination	Amoxicillin–Clavulanic acid and Piperacillin–Tazobactam

Note: The list of bacteria and drugs can be adjusted according to the changing situation.

Appendix D Performance indicators for the integrated AMR surveillance system in pilot settings

Indicators for surveillance system for case-finding based on priority of specimen sent routinely²³

1) Frequency of patients sampled, per specimen type per population

eg. Number of patients with urine culture per 100,000 population

2) Frequency of patients with growth of non-susceptible bacteria per specimen type, species and antibiotic

eg. Number of sampled patients with *E. coli* resistant to fluoroquinolones out of all patients sampled for blood culture

3) Proportion of sampled patients with positive culture of any (susceptible, intermediate or resistant) pathogenic bacteria per specimen type

eg. Number of patients sampled with positive blood culture out of all patients sampled for blood culture

4) Proportion of samples with growth of non-susceptible bacteria of the species, and antibiotic under surveillance per specimen type

eg. Proportion of *E.coli* non-susceptible to fluoroquinolones out of all tested.

Note: Surveillance system of case-finding based on priority specimen sent routinely is a system WHO requests Member States to enroll for an early implementation of Global Antimicrobial Resistance Surveillance System (GLASS). Indicators mentioned may be changed according to the latest version of GLASS method.

References

References

1. Carlet J, Collignon P, Goldmann D, et al. Society's failure to protect a precious resource: antibiotics. *Lancet*. 2011;378:369–371.
2. Carlet J, Jarlier V, Harbarth S, et al. Ready for a world without antibiotics? The Pensieres antibiotic resistance call to action. *Antimicrobial Resistance and Infection Control*. 2012;1(1):11.
3. Infectious Diseases Society of America. Combating antimicrobial resistance: policy recommendations to save lives. *Clinical Infectious Diseases*. 2011;52(5):S397–S428.
4. Sumpradit N, Suttajit S, Poonplosup S, et al. *Landscape of antimicrobial resistance situations and actions in Thailand 2015*.
5. O'Neill J. Antimicrobial resistance: tackling a crisis for the health and wealth of nations. *Review on antimicrobial resistance* 2014.
6. Pumart P, Phodha T, Thamlikitkul V, et al. Health and economic impacts of antimicrobial resistance in Thailand. *Journal of Health Systems Research*. 2012;6(3):352–360.
7. Jitraknatee A. Antibiotic values. In: Kiatying-Angsulee N, Kessomboon N, Maleewong U, eds. *Situation report on drug system 2010: antimicrobial resistance and antibiotic use*. Bangkok: Usa; 2011:21–25.
8. Apisarnthanarak A, Danchaivijitr S, Khawcharoenporn T, et al. Effectiveness of education and an antibiotic-control program in a tertiary care hospital in Thailand. *Clin Infect Dis*. Mar 15 2006;42(6):768–775.
9. Aswapokee N, Vaithayapichet S, Heller RF. Pattern of antibiotic use in medical wards of a university hospital, Bangkok, Thailand. *Rev Infect Dis*. Jan–Feb 1990;12(1):136–141.
10. Thamlikitkul V, Apisitwittaya W. Implementation of clinical practice guidelines for upper respiratory infection in Thailand. *Int J Infect Dis*. Jan 2004;8(1):47–51.

11. Udomthavornsak B, Tatsanavivat P, Patjanasoontorn B, et al. Intervention of inappropriate antibiotic use at a university teaching hospital. *J Med Assoc Thai* 1991;74(10):729–736.
12. Phanphanit R, Chariyalertsak S, Siviroj P, et al. Antibiotic prescription rates for upper respiratory tract infections in Thai national health insurance systems. *Journal of Health Science*. 2003;12:522–529.
13. Apisarnthanarak A, Mundy LM. Comparison of methods of measuring pharmacy sales of antibiotics without prescriptions in Pratumthani, Thailand. *Infection Control and Hospital Epidemiology* 2009;30(11):1130–1132.
14. Boonyasiri A, Tangkoskul T, Seenama C, et al. Prevalence of antibiotic resistant bacteria in healthy adults, foods, food animals, and the environment in selected areas in Thailand. *Pathogens and Global Health*. 2014;108(5):235–245.
15. Katein P. Agriculture Newsletter. *Against the citrus greening diseases*. 2013; <http://wangchin.phrae.doae.go.th/news/april2014/news4/news4.pdf>.
16. Nordmann P, Naas T, Poirel L. Global Spread of Carbapenemase producing Enterobacteriaceae. *Emerging Infectious Diseases*. 2011;17(10):1791–1798.
17. Liu Y–Y, Wang Y, Walsh TR, et al. Emergence of plasmid–mediated colistin resistance mechanism MCR–1 in animals and human beings in China: a microbiological and molecular biological study. *Lancet Infectious Dis*. 2015;DOI: [http://dx.doi.org/10.1016/S1473-3099\(15\)00424-7](http://dx.doi.org/10.1016/S1473-3099(15)00424-7).
18. Public Health England. *First detection of plasmid–mediated colistin resistance (mcr–1 gene) in food and human isolates in England and Wales (Serial number 2015/090)*. London: PHE; 2015.

19. Olaitan AO, Chabou S, Okdah L, et al. Dissemination of the mcr-1 colistin resistance gene. *Lancet Infect Dis.* 2016;16(2):147–149.
20. World Health Organization. Joint external evaluation tool: International Health Regulations (2005). Geneva, Switzerland; 2016.
21. Patton MQ. *Developmental evaluation: applying complexity concepts to enhance innovation and use.* New York: Guilford Press; 2011.
22. The development of the Thai Surveillance of Antimicrobial Consumption (Thai-SAC) and the National Drug Account (NDA) Program. 2016.
23. World Health Organization. *Global Antimicrobial Resistance Surveillance System: manual for early implementation.* Geneva, Switzerland; 2015.