Stopping the Grand Pandemic: A Framework for Action

Addressing Antimicrobial Resistance through World Bank Operations

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Contents

Chapter 3
Twenty Intervention Areas

Chapter 4
Investing in AMR through World Bank Operations

Chapter 5
Implementation Guidance for Investing in Interventions to Address AMR through World Bank Operations

Chapter 6

Tools to Support the Design and Implementation of Operations

Appendices

Tables

Boxes

Figures

Introduction

We rely on antimicrobials to save lives, bolster the resilience of health systems, protect the sustainability of food systems, and safeguard livelihoods…the inappropriate use of antimicrobials threatens their sustainability, and the devastating impact of this development, in which the drugs we know and rely on cease to work, is already emerging

Foreword

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In 1928, when Sir Alexander Fleming made the serendipitous discovery of penicillin, few could imagine how antimicrobials would transform societies, save lives, and enable livelihoods across the globe. Able to prevent a simple cut from becoming a death sentence and to support sustainable agricultural and food systems across the world, antimicrobials are powerful public goods and essential infrastructure. Importantly, they are a powerful tool for health security and economic development. They support communities around the world, many of whom are battling complex and multifaceted crises across the human health, climate, and environment nexus.

Yet the fight to preserve these powerful tools is being lost and a "Grand Pandemic" is already here. In 2019, antimicrobial resistance (AMR) was associated with close to 5 million deaths globally. That's more than the number attributed to HIV/AIDS or malaria—making AMR the world's third leading underlying killer. AMR impacts every community and every country, but the data show that those in low-income settings are disproportionately impacted. As the drugs stop working, we will lose our ability to treat diseases and perform life-enhancing surgeries, let alone to treat emerging pathogens of pandemic potential. As resistance is not confined to one pathogen but characterizes an increasing number of pathogens for which we have no medical countermeasures, the compounded impact of AMR on health, social, and economic outcomes across countries and regions stands to be staggering. Meanwhile, tackling AMR will save millions of lives, help our world to realize the Sustainable Development Goals, build resilient and sustainable societies, and increase human capital and productivity.

Much like COVID-19, AMR knows no borders. Addressing the spread of AMR requires improving health and animal systems at the local, regional, and country levels, and ensuring that those systems are connected. . The experience of the COVID-19 pandemic made clear the importance of sustainable investments in health systems in pursuit of eradicating poverty and boosting shared prosperity on a livable planet.

A new and actionable consensus—one that recognizes the importance of preventive action and specific investments to improve human, animal, and environmental health systems—is essential. Each country should help avert the Grand Pandemic. This Framework for Action is intended to support countries in designing and implementing interventions to address AMR. It provides options across the health, water, and agricultural sectors, evidence on how to shape those interventions, and examples of what has worked in multiple settings. This report showcases actions that have been and can be taken to address AMR. Moreover, the World Bank will support countries—with financing and technical assistance—in implementing these actions. The World Bank is currently supporting more than 60 operations that address AMR and remains committed to ensuring that communities all over the world have sustainable access to life-saving antimicrobials. The discovery of antimicrobials was one of the most important public health advances of the 20th century, and we hope to ensure that generations to come can benefit from these powerful tools.

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OF DENMARK

Abbreviations

Africa CDC	Africa Centres for Disease Control and Prevention
AGF	Agriculture and Food
AMC	antimicrobial consumption
AMR	antimicrobial resistance
AMS	antimicrobial stewardship
AMU	antimicrobial use
aPAD	antibiotic paper analytical device
ARG	antibiotic-resistant gene/antimicrobial-resistant gene
ASP	antimicrobial stewardship program
AST	antimicrobial sensitivity testing
ATLASS	Assessment Tool for Laboratory and Antimicrobial Resistance
AWaRe	access, watch, reserve
BSL	biosafety level
CERC	Contingent Emergency Response Component
CILSS	Permanent Interstate Committee for Drought Control in the Sahel
COP	Community of Practice
CSC	Country Steering Committee
DLI	disbursement linked indicator
DODRES	Disease Outbreak Detection and Response in East and Southern Africa
DPO	Development Policy Operations
ECCAS	Economic Community of Central African States
ECOWAS	Economic Organization of West African States
ECSA-HC	East, Central and Southern African Health Community
ENB	Environment, Natural Resources and the Blue Economy
E&S	environmental and social
ESBL	extended-spectrum beta-lactamase
ESCP	Environmental and Social Commitment Plan
ESF	Environmental and Social Framework
ESS	environmental and social standard
FAO	Food and Agriculture Organization of the United Nations
FAO-PMP-AMR	FAO Progressive Management Pathway for AMR

FELTP	Field Epidemiology and Laboratory Training Program (Nigeria)
FMARD	Federal Ministry of Agriculture and Rural Development (Nigeria)
FMOE	Federal Ministry of Environment (Nigeria)
FMOH	Federal Ministry of Health (Nigeria)
GLASS	Global Antimicrobial Resistance and Use Surveillance System
GMU	Grant Management Unit
GP	Global Practice
HCF	health care facility
HIC	high-income country
HNP	Health, Nutrition and Population
IBRD	International Bank of Reconstruction and Development
IDA	International Development Association
IEC	information, education, and communication
IEG	Independent Evaluation Group
IHR	International Health Regulations
IMSC	High-Level Inter-Ministerial Steering Committee (Indonesia)
IPC	infection prevention and control
IPF	Investment Project Financing
IR	intermediate results
JEE	Joint External Evaluation
LMICs	low- and middle-income countries
MDR	multidrug resistance/resistant
M&E	monitoring and evaluation
MoH	Ministry of Health
MPTF	Multi-Partner Trust Fund
NAP	National Action Plan
NAPHS	National Action Plan for Health Security
NCDC	Nigeria Centre for Disease Control
NiCaDe	Capacity Development for Preparedness and Response for Infectious Diseases
N-PCU	National Project Coordination Unit
NPHI	National Public Health Institute
NRL	National Reference Library (Nigeria)
NSC	National Steering Committee
NVRI	National Veterinary Research Institute
OECD	Organisation for Economic Co-operation and Development

PforRs	Programs for Results
PAD	paper analytical device
PCR	polymerase chain reaction
PCT	procalcitonin
PCU	Project Coordination Unit
PHC	primary health care
PIU	Project Implementation Unit
PRAPS	Regional Sahel Pastoralism Support Project
PVS	Performance of Veterinary Services
qPCR	quantitative polymerase chain reaction
RAP	Regional Advisory Panel
REDISSE	Regional Disease Surveillance Systems Enhancement
RKI	Robert Koch Institute
RSC	Regional Steering Committee
SACIDS	Southern African Centre for Infectious Disease Surveillance
SDG	Sustainable Development Goal
SF	substandard and falsified
TAP	Tailoring Antimicrobial Resistance Programmes
TB	tuberculosis
TC	Technical Committee
TISSA	Tripartite Integrated Surveillance System on AMR/AMU
TrACSS	Tripartite AMR Country Self-Assess¬ment Survey
UHC	universal health coverage
USAID	United States Agency for International Development
US CDC	United States Centers for Disease Control and Prevention
UTI	urinary tract infection
UV	ultraviolet
VMP	veterinary medical product
WAHO	West African Health Organization
WASH	water, sanitation, and hygiene
WHO	World Health Organization
WOAH	World Organisation for Animal Health
WWTP	wastewater treatment plant
XDR	extensive drug resistance

All dollar amounts are US dollars unless otherwise indicated.

Executive Summary

Antimicrobial resistance (AMR) is a global health security and development challenge that poses a threat to public health and economic prosperity. It is a challenge that is often overlooked. As antimicrobials have become part of the infrastructure of modern society, it has become all too easy to take them for granted; but their longevity is under threat. Antimicrobials and antibiotics are widely used for health, industrial, and agricultural purposes. In health care, they are inextricably linked to the advances in modern public health that societies have witnessed in recent decades. They have become a go-to medication for a variety of infections, from strep throat to sepsis. They have also become essential to agricultural and food systems and are used in crop and livestock management. Nevertheless, inappropriate use of antimicrobials threatens their sustainability, and the devastating impact of this development, in which the drugs we know and rely on cease to work, is already emerging. In 2019, an estimated 4.95 million deaths were associated with bacterial AMR, more than the number of deaths attributed to AIDS, HIV, and malaria—making AMR one of the world's biggest killers (Antimicrobial Resistance Collaborators 2022). The impact of AMR is not limited to human health. In 2017, the World Bank estimated that by 2050, unchecked AMR could wipe away 3.8 percent of global gross domestic product each year and push 28 million people into poverty (World Bank 2017).

In the face of this challenge, the World Bank stands ready to support governments in designing and implementing approaches to preserve antimicrobials with financing and technical assistance. This Framework for Action (Framework) aims to support World Bank task teams and clients in designing interventions that address AMR, with a focus on low- and middle-income countries (LMICs), which stand to be disproportionately impacted. This Framework outlines 20 intervention areas across the health, agriculture, and water sectors that can serve as starting points for discussions to develop sustainable systems addressing AMR at the national and regional levels. Tackling AMR is crucial to achieving universal health coverage, promoting good health, and attaining the Sustainable Development Goals (SDGs). To the challenge of addressing AMR, the World Bank brings operational expertise, finance, and the ability to mobilize additional resources for multisectoral programs through its operations and technical support.

The challenge posed by AMR is not universally intractable; from improving handwashing in health care settings to banning the use of antimicrobials as growth promoters in agriculture, there is much that can be done. The perceived complexity of AMR, lack of awareness about the steps that can be taken to address the issue, and insufficient financing have been identified as barriers to investing in relevant interventions. However, based on a review of existing evidence, the World Bank has identified several key intervention areas to highlight in the design and development of World Bank operations. These are shown in Table 1. This list is not exhaustive or intended to imply that other interventions are not as valuable, but rather aims to provide a starting point for action.

Table 1. Intervention Areas

Health

1. Improving infection prevention and control in health care settings
2. Improving prescribing practices through guidelines for health care workers
3. Conducting public awareness campaigns
4. Increasing human health laboratory capacity and access to diagnostics
5. Strengthening surveillance of antimicrobial use (AMU) and AMR in human populations

Agriculture and food

6. Increasing oversight of AMU by veterinarians
7. Monitoring AMU, surveillance of AMR, and increasing oversight in plant/crop production
8. Improving animal husbandry practice and biosecurity
9. Monitoring sales and use of antimicrobials and surveillance of AMR in animals
10. Promoting behavior change campaigns in animal production
11. Increasing veterinary laboratory capacity and access to diagnostics

Water and environment

12. Improving infrastructure to provide access to water and sanitation in health care centers
13. Implementing effective treatment and disposal of sewage and wastewater
14. Improving waste management practices in agricultural and aquaculture production/processing
15. Improving safe disposal of unused antimicrobials
16. Monitoring presence of antimicrobial residues and antibiotic-resistant bacteria and genes in water and sanitation systems

Multisectoral

17. Detecting and deterring substandard and falsified antimicrobials (customs/law enforcement/health/agriculture)
18. Improving human and animal nutrition (health/agriculture)
19. Expanding vaccination coverage in humans and animals (health/agriculture)
20. Using closed water systems in aquaculture (agriculture/environment)

While AMR is a multisectoral issue, sector-specific entry points are important for mobilizing prompt action. The driving forces behind AMR are shaped by actions in multiple sectors, but entry points for addressing AMR can be sector-specific. Several World Bank Global Practices—Health, Nutrition and Population (HNP), Agriculture and Food (AGF), Environment, Natural Resources and Blue Economy (ENB), and Water—and their relevant sectors can all play an important role, and their respective leadership is critical to ensuring that action is taken.

Each of the intervention areas can also be viewed as part of broader, comprehensive programming, and this report offers and discusses four thematic areas to enable countries to make informed choices about prioritizing and staging their approach to AMR management. The four thematic areas are reducing infections; strengthening monitoring and surveillance of AMR and antimicrobial use (AMU); improving the rational use of antimicrobials; and strengthening sectoral and multisectoral coordination and governance. Countries are at different states of readiness to address AMR, so a comprehensive approach may not always be feasible; however, a broader vision of the range of options can help maximize the effectiveness and sustainability of any given intervention. In instances where there is greater readiness, and where a strong enabling environment and political consensus to address AMR are present, comprehensive programming will be more feasible. In other settings, programming may need to be more opportunistic and targeted. Nevertheless, across different states of readiness, a vision of the range of options remains important, as it offers a window to ensuring that financial and nonfinancial resources are utilized well and sustainably. In all states of readiness, actions can be taken to address AMR.

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Chapter Guide

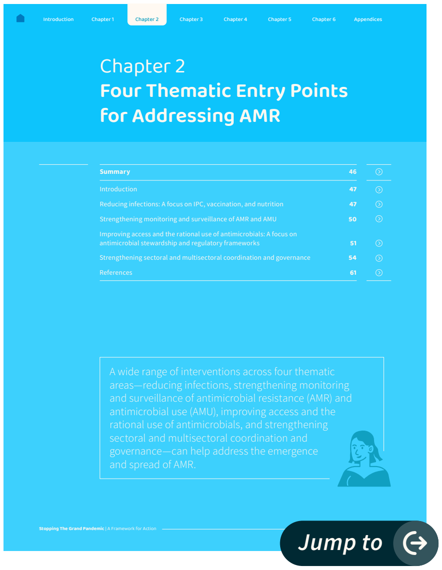
Chapter 1

Chapter 1 emphasizes the importance of addressing antimicrobial resistance (AMR) for global health security and development. The overuse and misuse of antibiotics is a growing concern that poses a significant threat to public health; it is a major driver of AMR. The consequences of AMR are far-reaching; they threaten the effectiveness of modern medicine and risk undoing decades of progress. The need for sustainable access to antimicrobials is paramount to the resilience of health systems. Addressing AMR is also critical to achieving the Sustainable Development Goals (SDGs), especially for low- and middle-income countries (LMICs). Without action, AMR could cause significant economic impact, wiping away up to 3.8 percent of global GDP and pushing millions of people into poverty. The responsible use of antimicrobials is a global public good that must be closely linked to achieving the SDGs and promoting healthy lives, ending poverty and hunger, and promoting sustainable and inclusive economic growth.

Jump to

Chapter 2

Chapter 2 describes packages of interventions across four thematic areas to show practitioners with how a given intervention can support comprehensive programming. The four thematic areas are reducing infections; strengthening monitoring and surveillance of AMR and antimicrobial use (AMU); improving access and the rational use of antimicrobials; and strengthening sectoral and multisectoral coordination and governance. A range of interventions across health, agriculture and food, and water and sanitation sectors are discussed in this chapter for global, regional, and national policy makers and implementers to consider from a thematic perspective. The chapter recognizes that different countries may have varying levels of preparedness to tackle AMR, and that a comprehensive approach may not always be feasible. Nevertheless, it stresses the importance of having a broader understanding of the available options to maximize intervention effectiveness and sustainability. Additionally, the chapter makes clear that a robust enabling environment and political consensus to address AMR are essential for comprehensive programming, but that in settings where readiness and funding are limited, more targeted, sector-specific, and opportunistic programming may be necessary.



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Chapter 3

Chapter 3 provides decision-makers and implementers with 20 intervention areas that can be supported through World Bank operations to address AMR. Recognizing that there are barriers to investing in these interventions (e.g., the complexity of the issue, lack of awareness about the issue, and insufficient financing), the chapter aims to facilitate better understanding of interventions to address AMR and so promote funding for them. The interventions are based on findings from a review of evidence and serve as a starting point for discussions between task teams and clients. These interventions are grouped by sector, in recognition of the organization of government ministries. The interventions include measures such as infection prevention and control, vaccination programs, improved hygiene and sanitation, enhanced laboratory capacity for AMR testing, and establishment of national and regional surveillance systems. Other interventions focus on improving access and rational use of antimicrobials, strengthening sectoral and multisectoral coordination and governance, addressing AMR in animal health, promoting research and development of new antimicrobial drugs and diagnostics, and strengthening health systems and capacity building. By highlighting these interventions, the World Bank aims to support global efforts in combatting AMR and safeguarding global health security and development gains. The list is not intended to be exhaustive or a prioritization but instead aims to highlight what can be done.

Jump to

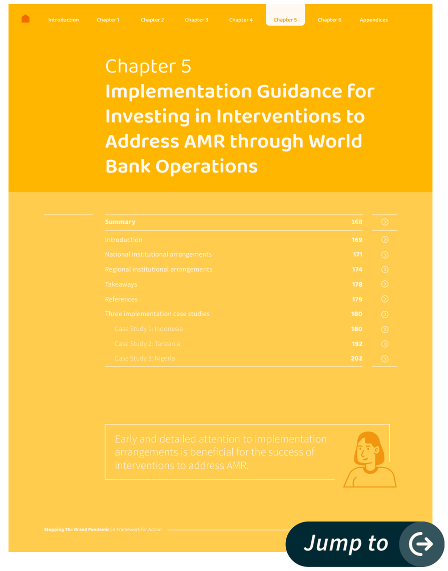
Chapter 4

Chapter 4 provides options for incorporating interventions to address AMR into World Bank operations, within and across Health, Nutrition and Population (HNP), Agriculture and Food (AGF), and Water Global Practices. The purpose of this chapter is to assist World Bank task teams and clients in incorporating interventions to address AMR in World Bank operations, including Investment Project Financing (IPF), Development Policy Operations (DPOs), and Programs for Results (PforRs). The chapter offers a menu of options for the design of operations, based on the interventions areas identified by staff members from the HNP, AGF, and Water Global Practices, as well as external partners such as the United States Centers for Disease Control and Prevention (US CDC), the World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO), and World Organisation for Animal Health (WOAH).

Jump to

Chapter 5

Chapter 5 provides implementation guidance based on the World Bank's operational experience and case studies of external experiences. The chapter is divided into two parts. The first part draws on experiences from World Bank operations and country cases to provide examples of implementation arrangements. The second part explores successes and challenges in addressing the AMR agenda in Nigeria, Indonesia, and Tanzania through country case studies. The chapter emphasizes the importance of early and detailed attention to implementation arrangements. Implementing interventions to address AMR can be challenging, not least because they can involve collaboration across multiple organizations and sectors. Many projects have strengthened national coordination bodies, which allow for multiple agencies within a sector and across sectors to be informed and have a stake in a project's success. Identifying senior advocates and high-level supporters from presidential and prime ministerial offices can benefit implementation by ensuring that the AMR agenda is elevated and prioritized and by providing neutrality between ministries. In addition, given that AMR is not confined by geographical boundaries, operations have drawn on regional mechanisms, both to support technical delivery and to receive and coordinate financing and project management. The case studies in the second part of the chapter discuss multisectoral and single-sector implementation initiatives using a One Health approach to build AMR surveillance and laboratory capacity.



Chapter 6

Chapter 6 provides task teams and clients with guidance on the range of tools that can be used to support project design and implementation. The chapter draws on the World Bank's Landscape Analysis of Tools to Address AMR, which identified over 90 tools for supporting investments in AMR. The tools are organized in terms of the project cycle across three categories: project identification, preparation, and appraisal; implementation; and completion and evaluation. Costing and financing have been identified as a challenge to addressing AMR in LMICs, and the chapter highlights tools that can be used for costing interventions. The chapter also highlights a range of tools that can be used to support the prioritization and leadership of sectors in mobilizing investments; given that only 20 percent of National Action Plans were fully funded in 2020, and 40 percent had a budgeted operational plan, such support is very much needed.

A Primer on AMR

What are antimicrobials and what is antimicrobial resistance?

Antimicrobials, a broad range of products that prevent the growth of or destroy bacteria, fungi, parasites, and even certain viruses, are essential tools that underpin modern society. Antimicrobials are critical to human and animal health systems as well as to the sustainability of food systems. They are widely used to prevent and treat diseases in humans and animals and to manage crop production. Antimicrobials are a global public good. All countries can benefit from the successful management of antimicrobial resistance (AMR) because if left unchecked, the world will confront a reality where many infectious diseases have "no cure and no vaccine" (World Bank 2017). No one has an interest in antimicrobials being exhausted. However, the world's collective response as each actor pursues short-term goals is leading to the loss of this vital global public good.

AMR refers to the ability of microbes and other infective organisms (e.g., fungi) and parasites (e.g., malaria) to grow in the presence of substances specifically designed to kill, inactivate, or slow their growth. AMR occurs when microbes change in ways that reduce or eliminate the effectiveness of drugs, chemicals, or other agents used to prevent or cure the infections they cause. When antimicrobial treatments stop working, as many have already, we lose the ability to treat infections effectively and quickly and, in some cases, even entirely. Pathogens, which are microbes that can cause disease, can also become resistant to multiple antimicrobials, leading to multidrug resistance (MDR), extensive drug resistance (XDR), and pan-drug resistance (PDR). MDR occurs when a pathogen is resistant to two or more antimicrobial agents in three or more antimicrobial classes. XDR occurs when a pathogen is resistant to at least one agent in all but two or fewer antimicrobial categories (i.e., bacterial isolates remain susceptible to only one or two categories). PDR is defined as resistance to all agents in all antimicrobial categories. Microbes that are resistant to multiple drugs can be referred to as "superbugs." An infection caused by a superbug is harder to treat because fewer drugs are effective against it. In some extreme cases, treatment for superbugs may not even exist. Box 1 describes three examples of resistant bacteria.

Box 1. Examples of Resistant Bacteria

Multidrug-resistant tuberculosis (MDR-TB):

Tuberculosis is caused by the bacterium Mycobacterium tuberculosis. MDR-TB is a form of the disease that is resistant to at least two of the most potent first-line drugs, isoniazid and rifampicin. MDR-TB presents a significant challenge to tuberculosis control due to various factors, including poor public health infrastructure, inadequate treatment, inefficient infection control, and the HIV epidemic, and it requires prolonged and complex treatment regimens. Surveillance gaps, especially in resource-constrained settings, contribute to under-detection of resistant TB, especially in children who often have culture-negative disease. In 2018, approximately 3.9 percent of new TB cases and 21 percent of previously treated cases were estimated to be MDR-TB (Prasad et al. 2018). In 2019, almost 85,000 deaths were attributable to Mycobacterium tuberculosis globally (Antimicrobial Resistance Collaborators 2022).

Multidrug-resistant Gram-negative bacteria:

Multidrug-resistant Gram-negative bacteria, like Klebsiella pneumoniae and Acinetobacter baumannii, are a growing concern in low- and middle-income countries (LMICs). Health care–associated infections caused by these resistant bacteria have reached prevalence rates of up to 24 percent in some settings, leading to prolonged hospital stays, increased health care costs, and a 2.3 times higher risk of mortality. These infections also complicate treatment, with failure rates exceeding 50 percent, and hinder medical interventions, such as surgical procedures, with a three-fold increase in postoperative complications (Elwakil 2023).

Methicillin-resistant Staphylococcus aureus (MRSA):

MRSA is a strain of the bacterium Staphylococcus aureus that has developed resistance to multiple antibiotics, including methicillin and other beta-lactams. MRSA infections are of particular concern in health care settings, where they can cause severe and sometimes life-threatening infections, especially among patients with compromised immune systems or surgical wounds. Infections with MRSA can lead to longer hospital stays and increased health care costs. MRSA infections are a pertinent concern in LMICs, especially in crowded health care settings with limited resources. The prevalence of MRSA varies widely across regions, with studies reporting rates as high as 80 percent among health care–associated infections in some LMICs. The mortality rate for MRSA infections can be as high as 50 percent, especially in critically ill patients with inadequate access to effective antibiotics (Siddiqui and Koirala 2023). In 2019, MRSA caused more than 100,000 deaths (Antimicrobial Resistance Collaborators 2022).

Why does AMR matter for people, animals, plants, and human and animal health systems?

We rely on antimicrobials to save lives, bolster the resilience of health systems, protect the sustainability of food systems, and safeguard livelihoods—both people's ability to work and agricultural economies more broadly. AMR matters because the more it grows, the greater the risk to life worldwide. In 2019, drug-resistant infections were a significant contributor to mortality, with an estimated 4.95 million people losing their lives due to such infections. Out of these deaths, 1.27 million were directly attributable to AMR. AMR was one of the world's biggest killer, responsible for more deaths than AIDS, HIV, and Malaria (Antimicrobial Resistance Collaborators 2022). At an individual level, the more intensive and prolonged treatment regimens required for AMR infections can lead to prolonged hospital stays for patients. As a result, there is a higher risk of catastrophic health expenditure, meaning that more people are vulnerable to poverty due to infections that were previously simpler and cheaper to treat.

People who live in poverty are also more susceptible to infectious diseases, enabling a harmful cycle that is complicated by AMR. At a health system level, AMR substantially increases the financial and nonfinancial resources needed to treat and manage diseases. The efficacy of antimicrobials is essential to the sustainability of livelihoods in the livestock and poultry sectors, as well as the agriculture and food sectors, especially in low- and middle-income countries (LMICs) where biosecurity and animal husbandry systems are still being developed.

What are the global trends in antimicrobial use and resistance?

Use of antimicrobials is expected to increase substantially in the coming decade, and this increase brings an increased risk of AMR. The 2021 report on the State of the World's Antibiotics (Sriram et al. 2021) found that global antibiotic consumption in humans increased 65 percent between 2000 and 2015, and consumption in animals was projected to increase by 200 percent between 2017 and 2030. Without action, overall antibiotic consumption could increase by 200 percent between 2015 and 2030.

AMR is on the rise, and resistance levels are generally higher in LMICs (Sriram et al. 2021). Antimicrobial resistance continues to rise; countries increasingly report high rates of resistance to antimicrobials used to treat common infections. Weighted average resistance levels are generally higher in LMICs. The recent Drug Resistance Index, which includes 41 countries, shows that while resistance and use rates vary across countries, high-income countries have lower resistance levels. Countries with the highest levels of drug resistance are all LMICs (Klein et al. 2019). Box 2 describes examples of viral, fungal, and protozoal drug resistance.

Box 2. Examples of Viral, Fungal, and Protozoal Drug Resistance

Viral drug resistance: Influenza antiviral resistance

Influenza viruses, including seasonal and pandemic strains, have developed resistance to certain antiviral drugs, such as oseltamivir (Tamiflu) and zanamivir (Relenza). Oseltamivir and zanamivir are neuraminidase inhibitors, which work by blocking a viral enzyme essential for the release of newly formed virus particles from infected cells. By inhibiting this enzyme, these drugs effectively reduce the spread and severity of influenza infections. However, influenza viruses can mutate and acquire genetic changes that make them less susceptible to the inhibitory effects of these drugs, leading to resistance. Antiviral resistance can reduce the effectiveness of treatment and limit options for managing flu outbreaks. Influenza viruses resistant to oseltamivir (Tamiflu) have been detected worldwide, with resistance rates varying each season. In some years, resistance to oseltamivir has been reported in up to 30 percent of tested samples (Smyk et al. 2022).

HIV drug resistance: HIV antiretroviral resistance

HIV can develop resistance to antiretroviral drugs used to manage the infection. Drug resistance can arise due to improper medication adherence or suboptimal treatment regimens, leading to treatment failure and disease progression. The global HIV drug resistance landscape shows significant variations between resource-rich and resource-limited settings. Globally, around 12 percent of people living with HIV who are receiving antiretroviral therapy have developed resistance to at least one of the drugs used in their treatment. In resource-limited settings, high rates of pretreatment and acquired drug resistance to non-nucleoside reverse transcriptase inhibitors (NNRTIs) and nucleoside reverse transcriptase inhibitors (NRTIs) have been reported, particularly in Sub-Saharan Africa. Surveillance data from 2014 to 2018 indicated prevalence of NNRTI pretreatment drug resistance above 10 percent in 12 out of 18 low- and middle-income countries (Nachega et al. 2011).

Fungal drug resistance: Multidrug-resistant Candida auris

Candida auris is a multidrug-resistant fungus that can cause severe infections. This emerging pathogen is resistant to many antifungal drugs, making outbreaks in health care facilities challenging to treat and control. Since its identification in 2009, Candida auris has spread to over 30 countries, with several outbreaks reported in health care facilities. One of the most concerning aspects of Candida auris is its resistance to many commonly used antifungal drugs, including azoles, echinocandins, and polyenes. This extensive resistance profile makes it exceptionally challenging for health care providers to effectively treat infections. Moreover, the limited arsenal of antifungal drugs available further exacerbates the difficulty in managing Candida auris infections, leaving health care facilities grappling with the urgent need to develop alternative treatment strategies. The propensity of Candida auris to thrive in health care environments adds to the complexity of controlling its spread. The fungus can persist on environmental surfaces, medical equipment, and even health care workers' hands, facilitating transmission between patients. Nosocomial outbreaks have been widely reported, leading to heightened infection control measures and a strain on health care resources. Patients with invasive Candida auris infections face grave outcomes, with mortality rates reaching as high as 60 percent (Sanyaolu et al. 2022).

Protozoal Drug Resistance

Artemisinin-resistant Plasmodium falciparum: Plasmodium falciparum is the parasite responsible for the most severe form of malaria. Some strains have developed resistance to artemisinin-based combination therapies, which are the most effective treatments for malaria. Artemisinin resistance has been reported in several countries in Southeast Asia, including Cambodia, Thailand, Myanmar, and Vietnam, where certain strains of the parasite have shown reduced susceptibility to artemisinin drugs. As the parasite's resistance to this critical class of antimalarials spreads, it compromises the efficacy of ACTs, rendering them less effective in clearing the infection and reducing the risk of treatment failure. This resistance threatens malaria control efforts and can lead to increased malaria-related morbidity and mortality. Artemisinin resistance is a major concern as it threatens the success of malaria control and elimination efforts (Ouji et al. 2018).

What causes AMR?

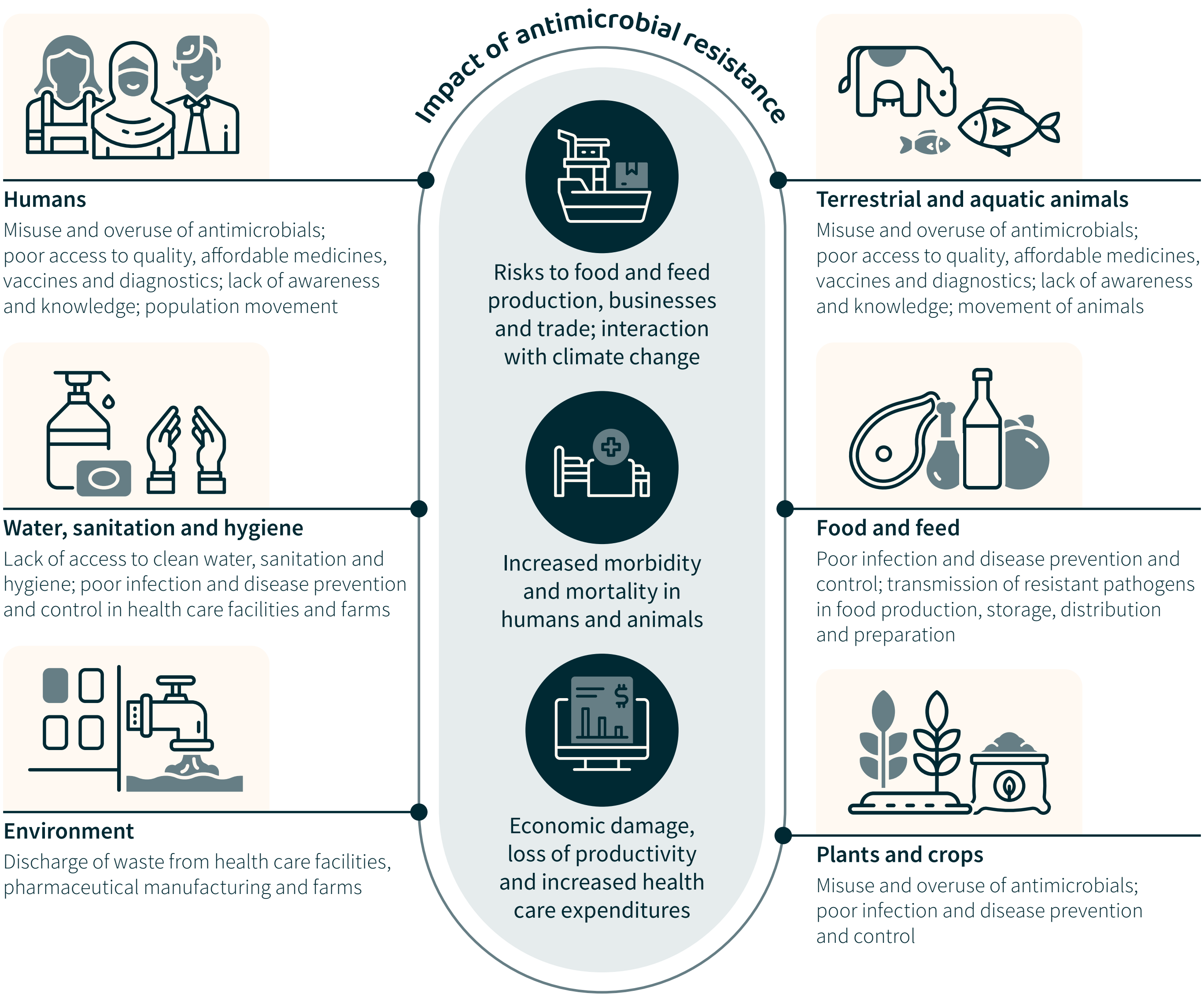
AMR is driven by actions in multiple sectors, and the misuse and overuse of antimicrobials drives the emergence and spread of resistance. AMR is a naturally occurring phenomenon that results from the mutations in and transfers of genetic material between different microbes. Any use of antimicrobials can result in AMR. Misuse and overuse of antimicrobials—for example, when people take substandard antibiotics for viral infections and when antibiotics are used as growth promoters in animals—increases the likelihood of resistance because it offers more opportunities for pathogens, bacteria, and parasites to overcome antimicrobials. Equally, when people cannot access the antimicrobials they need because they are not available, unaffordable or no longer effective, this makes infections difficult to treat and adds to the burden on healthcare systems.

Misuse and overuse of antimicrobials, a major driver of AMR, is shaped by actions in multiple areas, as shown in Figure 1. The spread of microbes resistant to antimicrobials can occur between people, animals, and plants and across the environment (in water, soil, and air). As highlighted by the World Health Organization (WHO), poor hygiene and infection control, inadequate sanitary conditions, and inappropriate food handling all contribute to the spread of AMR. AMR drivers operate through a range of causal pathways that lead to high-risk conditions for AMR emergence and spread. Table 17 (see Appendix 2) provides a summary of drivers and pathways. For example, inadequate regulation of antimicrobials in health and agriculture, or inadequate enforcement of legislation, can be a driver of AMR. The pathways related to regulation include overuse and inappropriate use of antimicrobials in health care settings, the widespread presence of substandard and falsified antimicrobials, the availability of over-the-counter antimicrobials (i.e., those dispensed without a prescription), and the lack of new antimicrobial treatments being approved and become available. In the agricultural and food sectors, antimicrobials are widely used to enhance animal growth, raise animal productivity, and prevent diseases in crops.

The lack of good animal husbandry practices, lack of space for isolating sick animals, and lack of veterinary expertise contribute to the inappropriate reliance on antimicrobials to bolster animal health systems.

The pathways that result in AMR are often complex and multifaceted; however, actions can be taken across all sectors to reduce the misuse and overuse of antimicrobials. The Framework for Action describes and provides guidance on 20 intervention areas that can be supported through World Bank operations. The perceived complexity of AMR, lack of awareness about the steps that can be taken to address the issue, and insufficient financing have been identified as barriers to investing in relevant interventions. Chapter 3 describes intervention areas of varying scope and scale that contribute to broader programming areas, as well as findings from a review of evidence to support task teams and clients. This list is not exhaustive or intended to imply that other interventions are not as valuable, but rather aims to provide a starting point for action.

Figure 1. Drivers of Antimicrobial Resistance



Source: IACG 2019.

What sectors are relevant to AMR?

AMR is a problem that affects and is driven by interconnected factors related to people, animals, plants, and ecosystems across a range of sectors, including health, agriculture, food, water and sanitation, and the environment. These sectors are all relevant to mitigating the rising tide of AMR.[1] Actors within each of these sectors can each take on leadership in addressing AMR. In the health sector, for example, improved prescription practices and vaccination programming can mitigate AMR. Collaborations between sectors can also be powerful and effective. For example, improving sanitation and hygiene through improved infrastructure for clean water in hospital settings can reduce the emergence and spread of disease and reduce the need for antibiotics.

Given the connections between sectors, AMR has been described as a "One Health" issue, and this concept is important for understanding how approaches to addressing AMR can be optimized. One Health is defined as "an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems" (WHO 2021).[2] In terms of practice, a One Health approach involves collaboration and integrated programming and recognizes the interconnected nature of human, animal, and ecosystem health in managing global health security threats. Coordinated One Health action can optimize scarce resources to minimize the emergence and spread of AMR. For example, a disease surveillance system that can monitor the use and rise of resistance in both the animal and human health sectors stands to be more effective than a single-sector surveillance system, given that similar antimicrobials are used in both sectors.

However, it is recognized that relying on coordination across sectors can stifle action, so single-sector actions that are cognizant of multisectoral links can be a critical first step. The challenge of coordinating across different sectors, each of which can have competing demands, budgets, and interests, can lead to inaction. Therefore, while multisectoral programming is often an excellent way to optimize scarce resources and is advised, each sector should also understand how its leadership can advance action to address AMR and how such action can enable current or future action in other sectors. For example, a disease surveillance system in the human health sector can be designed and implemented with an understanding of how it will connect with—and engage with stakeholders in—the veterinary and animal health sector.

1 In the context of the World Bank, these sectors are housed under two vice presidencies: Human Development and Sustainable Development. Human Development includes the Health, Nutrition and Population (HNP) Global Practice (GP). Sustainable Development includes the Agriculture and Food (AGF) GP and the Water GP. These GPs work together in areas of crossover; for example, HNP and Water often collaborate on sanitation and hygiene projects.

2 The definition was developed by the One Health High Level Expert Panel (OHHLEP), which is the advisory panel of the Food and Agriculture Organization of the United Nations, World Organisation for Animal Health, United Nations Environment Programme, and World Health Organization.

What types of interventions are there to address AMR?

Box 3. Definitions: AMR-Sensitive and AMR-Specific Interventions

AMR-specific interventions have as their main purpose the reduction of AMR emergence and spread. An example is the promulgation and enforcement of regulations to ensure people can obtain antimicrobial medicines only with a valid prescription.

AMR-sensitive interventions have other primary purposes (such as improved animal husbandry or a reduction in disease incidence through vaccination) but contribute indirectly to addressing emergence and spread of AMR. They can be designed and delivered to maximize their impact on AMR.

Actions to address AMR can be divided into two categories: AMR-specific and AMR-sensitive (see Box 3). AMR-specific interventions led by the relevant sectors can play a powerful role in addressing AMR. For example, in health, AMR can be addressed by improving prescription practices to increase the rational use of antibiotics and limit unnecessary prescription (e.g., of antibiotics for viral infections). In agriculture, reducing and eliminating the use of antimicrobials as growth promoters and facilitating the uptake of improved husbandry practices have been shown to reduce AMR.[3] Actions to address AMR can also be built into the approach across sectors. These AMR-sensitive approaches are based on the recognition that AMR is driven by anthropological and socioeconomic factors (Collignon et al. 2018), that the spread of resistant strains and genes is a dominant factor in the rise of AMR, and that reducing antimicrobial use alone will not be sufficient to address AMR. Improving sanitation, increasing access to clean water, and improving governance and private health sector regulation are examples of AMR-sensitive measures that are necessary to reduce the emergence and spread of AMR.

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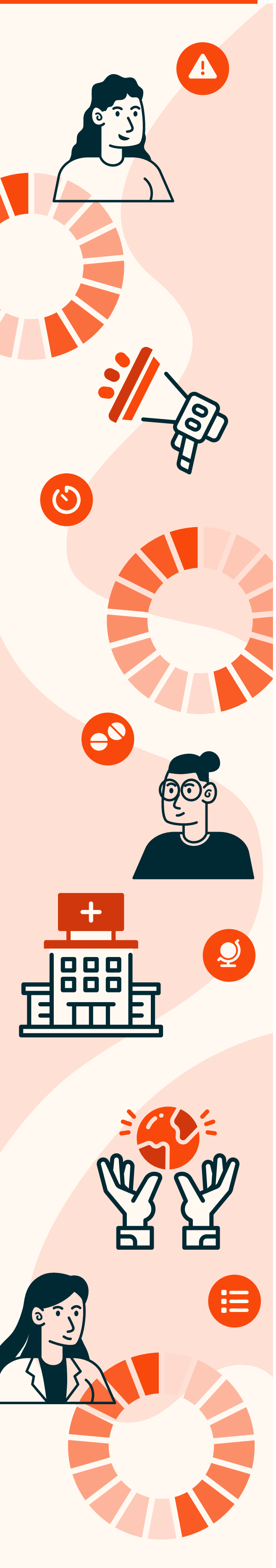
Chapter 1
Why Addressing AMR Remains Critical to Global Health Security and Global Development

Addressing AMR is a development challenge that will negatively and disproportionately impact low- and middle-income countries… by 2050, a high-AMR scenario could wipe away 3.8 percent of global gross domestic product each year and push 28 million people into poverty.



Chapter 1
Why Addressing AMR Remains Critical to Global Health Security and Global Development

Chapter 1 summary

In 2019, antimicrobial resistance (AMR) was one of the biggest killers worldwide—yet it remains a neglected threat to global health security. Despite AMR's substantial global impact to date, and the recognition that, if unchecked, AMR stands to kill more than 10 million people each year by 2050 (Antimicrobial Resistance Collaborators 2022), AMR is often overlooked, and antimicrobials taken for granted.

Addressing AMR is critical to global health security because antibiotics are an essential tool for quickly and effectively managing and preventing disease. The lack of sustainable access to antimicrobials threatens basic and modern medicine and risks undoing public health gains of the last century. Antimicrobials are vital to the resilience of health systems: they are a first line of defense for a host of health conditions, from minor wounds to complex surgeries, and they enable health systems to manage routine care and respond to shocks such as pandemics.

Addressing AMR is a development challenge that will negatively and disproportionately impact low- and middle-income countries (LMICs). By 2050, a high-AMR scenario could wipe away 3.8 percent of global gross domestic product each year and push 28 million people into poverty (World Bank 2017). Antimicrobials are a global public good that are entwined with our ability to meet the Sustainable Development Goals (SDGs). They are vital to our ability to sustain and improve global reductions in child and maternal mortality, to end extreme poverty and promote shared prosperity, to end hunger, to promote healthy lives and well-being, and to achieve sustainable and inclusive economic growth.

The purpose of this Framework for Action is to support task teams and clients in designing components of World Bank operations and in addressing AMR through investments across sectors. The Framework presents 20 intervention areas across the health, agriculture, and water sectors that can help to address AMR. The selected interventions are not intended to provide an exhaustive or definitive list. Rather, they are intended as a starting point for discussions between task teams and clients that can facilitate the development of sustainable systems to address AMR in the short, medium, and long term, at both the country and regional level.

Antimicrobial resistance as a threat to global health security and global development

In 2019, antimicrobial resistance was one of the biggest killers worldwide (Antimicrobial Resistance Collaborators 2022); despite this substantial impact on global health security, AMR is often overlooked. Despite its substantial global impact to date, and the recognition that, left unchecked, AMR stands to kill more than 10 million people each year by 2050, AMR is often overlooked, and the power of antimicrobials is taken for granted. Nevertheless, no one is immune from the threat of AMR, and citizens of LMICs stand to be disproportionately and negatively impacted. By 2050, a high-AMR scenario could wipe away 3.8 percent of global gross domestic product each year and push 28 million people into poverty (World Bank 2017).

Addressing AMR remains critical to the future of global health security and global development, as antimicrobials are essential for managing human and animal health systems, ensuring the sustainability of our food systems, and protecting life as we know it today. Antimicrobials have become critical infrastructure within modern society; therefore, AMR has the potential to upend ordinary life (World Bank 2019. Antimicrobials are used every day for a wide range of animal and human health needs. They have become commonplace across modern medicine and are used to treat people with infected bites and wounds, patients undergoing complex surgeries, cancer and heart failure patients, and women delivering babies, as well as children, the elderly, and people with HIV or with weakened immune systems. Antimicrobials are also used to treat sick animals and to control the spread of disease.

The misuse and overuse of antimicrobials has accelerated AMR, which is aggressively threatening the ability of health systems to manage disease quickly and effectively—in terms of both the quality and cost of care. The treatment of tuberculosis (TB) highlights the negative impact of AMR. In 2019, nearly half a million people developed rifampicin-resistant TB, 78 percent of whom were infected with multidrug- or extensive drug-resistant (MDR-TB or XDR-TB) isolates (WHO 2020a). Drug-resistant TB poses a significant economic threat to households, as treatment can cost up to 25 times more than for drug-susceptible strains and take three times longer to cure (Manjelievskaia et al. 2016). Among people with MDR-TB or XDR-TB and their households, 80 percent face catastrophic costs associated with treatment (defined as costs greater than 20 percent of annual household income) (WHO 2020a).

Building sustainable systems across human, animal, and environmental health, as well as water and sanitation, can help keep AMR at bay and preserve vital resources for decades to come. The experience of the COVID-19 pandemic has crystallized the importance of sustainable investments to build and develop the systems that keep citizens and economies around the world healthy. The ability of these systems to support their own sectors, as well as work across sectoral boundaries, will be an important enabler of long-term recovery from COVID-19 and of our collective ability to eradicate poverty and boost shared prosperity. The widespread importance of antimicrobials to modern life requires improving the capacity of health and animal systems at the local, regional, and country levels, and improving the ability of systems to connect, work, and collaborate with other systems. For example, a local surveillance network that connects to a national and regional system will be better placed to understand trends and transmission patterns of resistance, support the development of mitigation measures, and preserve the efficacy of essential medicines. This type of investment can optimize the use of antimicrobials as public goods.

The world remains at a critical juncture in translating the experience of COVID-19, which painfully demonstrated the importance of strong systems, into tangible investments that safeguard our collective future with global public goods such as efficacious antimicrobials. COVID-19 drove an additional 97 million people into extreme poverty in 2020 (World Bank 2021). A new and actionable consensus—one that recognizes the importance of preventive action and specific investments to improve human, animal, and environmental health systems—is essential. Without it, critical tools such as antimicrobials will not be safeguarded, and our ability to manage disease will be severely limited. The Framework aims to move the global community toward a consensus by highlighting what can and ought to be financed to build systems that preserve the efficacy of antimicrobials.

Interventions to address AMR are among the most cost-effective investments that can be made in the health and agricultural sectors, and the economic case for action has been clearly established. The emergence of drug-resistant pathogens is inevitable, but widespread AMR can be controlled through interventions in health, agriculture, water and sanitation, and environmental sectors, as well as many others, as it is accelerated by human behavior. Health systems perform the core functions of early detection and of prompt and effective control of AMR. In 2012, spending on these systems was identified as having a high expected economic return (57–86 percent a year) (World Bank 2012). In 2019, the Organisation for Economic Co-operation and Development (OECD) conducted an analysis of progress toward tackling the burden of AMR in high-income countries and found that investing €1.5 per capita per year in a comprehensive package of mixed public health interventions would avoid 27,000 deaths per year in the European Union. Moreover, the package of interventions would pay for itself in one year alone and return approximately €1.4 billion in savings (OECD 2019). Across the OECD, interventions to promote the prudent use of antibiotics in hospitals were costed at US$0.3 to US$2.7 per capita per year in many OECD countries (OECD 2018).

Despite this compelling economic case at the global level, many factors have hindered progress on AMR, including the nature of antimicrobials as global public goods, the need for multisectoral solutions with an integrated systems perspective, the perception of complexity, general lack of awareness, and financing gaps. In 2020, the Wellcome Trust noted that action on AMR has entered a "state of paralysis" (Wellcome 2020a, 11); several barriers have inhibited movement from consensus on the importance of AMR to coordinated action and financing for addressing AMR. One challenge relates to communicating the importance of AMR to policy makers, budget holders, and the general public, given the perceived complexity of the topic. As the shared experience with COVID-19 has shown, simple measures—improved hand hygiene and improved infection prevention and control measures in hospital and everyday settings—can have a powerful impact on the spread of disease. Responding to AMR is no different. The Framework seeks to facilitate increased financing to address AMR by specifying relevant actions and tools that the World Bank and other international financial institutions can use to support countries across the income spectrum.

The under-recognition of AMR as a global threat may be attributed to various factors, including funding challenges, the long-term nature of the AMR challenge, and the complex nature of AMR and its multifaceted impact on health systems, economies, and societies. Results for the 2019–2020 Tripartite AMR country self-assessment survey (TrACSS 4.0) conducted by the World Health Organization (WHO) among implementers of National Action Plans (NAPs) highlighted the critical issue of funding as the primary challenge to effective AMR action. The survey revealed that a significant gap exists between the recognition of the problem and the availability of financial resources to address it. As of 2020, only 14 percent of NAPs had been costed and funded, indicating a considerable shortfall in financial support for AMR initiatives (WHO 2022). The consequences of inadequate funding extend beyond the immediate challenges of combating AMR. Insufficient financial support limits the capacity to raise awareness, educate health care professionals and the public, and develop innovative solutions to tackle AMR. It perpetuates a cycle of limited resources, hindering the development of new antimicrobial drugs, diagnostic tools, and infection prevention measures that are crucial for effectively managing resistant infections.

Securing funding for such comprehensive initiatives can be challenging, especially when resources are limited, and competing priorities exist. Additionally, unlike immediate health crises or emergencies, the consequences of AMR may not be readily apparent or easily quantifiable. This can lead to a perception that investing in AMR prevention and control measures is less urgent than for other pressing health care issues. Moreover, the lack of awareness about the potential catastrophic consequences of AMR among policy makers and the general public can contribute to a reduced sense of urgency and, consequently, limited funding. Efforts to raise awareness about AMR, its impacts, and the importance of investing in prevention and control strategies are crucial to mobilize financial support.

Another example of under-recognition of AMR is the lack of market incentives for the antimicrobial research and development pipeline. R&D for new antimicrobial drugs has experienced a significant decline since the 1980s (Wellcome Trust 2020b), and the current state of the pipeline can be described as inadequate. This decline can be attributed to various factors. One key factor is the high cost associated with conducting R&D for antimicrobials. Antimicrobials may not be as commercially attractive when compared with drugs that require prolonged usage and can command high prices. This lack of commercial viability diminishes the incentives for pharmaceutical companies to invest in the development of new antimicrobial drugs. Without strong economic incentives, there is limited motivation for pharmaceutical companies to allocate resources to antimicrobial research. As a result, the pipeline for new antimicrobial drugs remains stagnant, with fewer potential treatment options being developed. Given this scenario, it becomes increasingly crucial to preserve the effectiveness of existing antimicrobial drugs by minimizing their misuse and overuse, and ensuring sustainable access plans for the few new drugs that become available. By preventing the emergence and spread of antimicrobial resistance through appropriate and responsible use, the available drugs can be preserved for as long as possible.

Individuals, governments, regional entities, multilateral organizations, and development banks all play a role in a proactive response to AMR. Many steps have already been taken, but an unfinished agenda remains. Step one is designing and developing investments to build the strength and resilience of existing systems across the One Health spectrum. The investment case is familiar and clear. Following the COVID-19 pandemic, there is an important opportunity to rebuild systems so they are resilient to future global health security threats. The current moment is a watershed that offers significant opportunities to build human health systems, animal health systems, and food systems that are more proactive, effective, and resilient.

An extensive body of work has already set out the importance of addressing AMR and strengthening systems for human, animal, and environmental health to achieve the broader goal of safeguarding antimicrobial effectiveness. The international community recognized the importance of AMR as a global health security threat at the May 2015 World Health Assembly, through the adoption of the World Health Organization (WHO) Global Action Plan on AMR. In 2017, the World Bank analyzed the economic impact of AMR at the global level (World Bank 2017), and in 2019 it identified implementation gaps affecting AMR (World Bank 2019). An OECD (2018) report, *Stemming the Superbug Tide*, presented the critical financing gap by showing that too few countries have financing in place for their AMR NAPs. As of November 2022, 170 countries had established such plans, which commit countries to aligning with the Global Action Plan. National Action Plans for Health Security (NAPHSs) also include interventions on AMR, making their implementation more broadly relevant. Most recently, at the global level, a report by the United Nations Interagency Coordinating Group on Antimicrobial Resistance (IACG 2019) highlighted the importance of investing for a sustainable response. It stressed the need for increased investments to finance NAP implementation, among other interventions.

Countries around the world have begun to operationalize a focus on AMR through NAPs; however, financing and implementation have been substantial barriers. Countries with multisectoral NAPs have found it challenging to prioritize, resource, and monitor them, and implementation of activities has often been ad hoc. At the same time, these plans provide a valuable foundation for a response to AMR, and increasing financing to support part or all of a plan is a tangible action that countries can take to preserve the sustainability of systems across different sectors. In addition, as indicted just above, activities to address AMR are also included in NAPHSs, and for many countries, where AMR activities fall under the purview of health emergency teams, these plans can be another important vehicle for identifying and prioritizing investments and interventions.

Given its multisectoral drivers, AMR is also closely aligned with the One Health agenda (CDC 2022). A One Health approach can be defined as:

> *an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, plants and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent. The approach mobilizes multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective need for clean water, energy and air, safe and nutritious food, taking action on climate changes and contributing to sustainable development (OHHLEP 2022).*

Addressing AMR can benefit from a One Health approach because the antimicrobials used to treat infectious diseases in humans may be the same as or similar to those used in animals, and resistant bacteria arising in humans, animals, or the environment can spread from one domain to the others (WHO 2021a). The One Health Joint Plan of Action (2022–2026) launched by the Quadripartite organizations includes curbing AMR as one of its six action tracks (FAO et al. 2022).[4]

A One Health approach can help to maximize the effectiveness and sustainability of interventions and can also be cost-effective. Where collaboration across sectors is possible, a One Health approach in the design and implementation of programs, policies, legislation, and research can allow all sectors to benefit from collaboration, coordination, communication, and capacity strengthening. It is important to acknowledge that multisectoral action is not always possible; but where sectors can tackle AMR together there is scope to achieve critical human, animal, and environmental health outcomes (WHO 2021b). A multisectoral, One Health approach can help to mitigate AMR's emergence and spread in all domains, and it also offers benefits in related areas such as food safety and food security, biosecurity and animal welfare, WASH (water, sanitation, and hygiene), pollution reduction, emerging infectious disease prevention, and pandemic preparedness and response.

4 The Quadripartite members are the Food and Agriculture Organization of the United Nations (FAO), the United Nations Environment Programme (UNEP), the World Organisation for Animal Health (WOAH, founded as OIE), and the World Health Organization (WHO).

Purpose of the Framework for Action

This Framework is intended to support task teams and clients in designing components of World Bank operations and addressing AMR through World Bank operations across multiple sectors. This Framework describes 20 intervention areas across the health, agriculture, and water sectors that can help to address AMR. The selected interventions are not intended to provide an exhaustive or definitive list. Rather, they are intended as a starting point for discussions between task teams and clients that can facilitate the development of sustainable systems to address AMR in the short, medium, and long term, at both the country and regional level. More specifically:

» The Framework for Action summarizes the current state of evidence, the feasibility of implementing projects across different settings, and considerations for optimizing implementation for 20 intervention areas.

» It provides practical guidance on developing approaches to prevent, detect, respond to, and mitigate the emergence and spread of AMR in low- and middle-income settings.

» It provides a starting point for sectoral leadership and alignment both within and beyond the World Bank.

» It highlights approaches to institutional arrangements that support multisectoral implementation.

» It presents existing tools and innovations that can be drawn upon to support successful implementation.

Audience

The World Bank has both an internal and external audience in its work on AMR. The Framework is intended primarily as a resource for World Bank staff and clients who have an interest in accelerating financing to address AMR. Task team leaders will be able to draw on the Framework for guidance when structuring components, lessons learned from implementation arrangements and descriptions of existing tools and guidance. Management may benefit from the Framework's articulation of options for sectoral entry points, leadership, and collaboration across Global Practices (GP), including Health, Nutrition and Population (HNP), Agriculture and Food (AGF), Environment, Natural Resources and the Blue Economy (ENB), and Water, as well as global themes like climate change and gender. Beyond the World Bank, organizations and other stakeholders with a shared interest in addressing AMR may find the Framework useful for articulating the role that international financial institutions can play and identifying useful entry points for them.

Rationale for World Bank involvement

AMR's disproportionate impact on LMICs makes it a development problem that warrants support from development financing organizations; its relationship to the Sustainable Development Goals and its impact on inequity provide an additional rationale for involvement. As highlighted by the World Bank's (2019) report, AMR is a development issue—and one that could prevent the attainment of the SDGs.[5] A rise in drug-resistant infections and a diminishing ability to rely on antimicrobials compromise advances made in public health over the last century. AMR not only jeopardizes the prospect of ending extreme poverty and promoting shared prosperity, but also compromises the ability to end hunger, promote healthy lives and well-being, and achieve sustained economic growth. Table 2 highlights the relationship between AMR and the SDGs.

Table 2. AMR and the SDGs

Core SDGs	How AMR impedes progress on the SDG	How progress on the SDG helps to address AMR
1 NO POVERTY	• People living in poverty are more prone to infectious diseases, and resistant infections are more likely to spread in poor living conditions. The poor are less able to access effective treatment. Substandard care and partial treatment can drive infection. • High costs of treatment and chronic infections will impoverish millions. An additional 28.3 million people could be pushed into extreme poverty by 2050 because of AMR, most of them living in LMICs (World Bank 2017).	• Financial and social protection strategies will allow poor people to access good-quality services and decrease the impact of AMR.
2 ZERO HUNGER	• AMR in animals increases costs of animal health, infections become untreatable, production decreases and working animals cannot carry out their tasks, affecting the livelihood of farmers and food security. • Livestock production in low-income countries would decline the most, with a possible 11 percent loss by 2050 in the high-AMR impact scenario (World Bank 2017).	• Developing sustainable food production systems with less reliance on antimicrobials and with the phasing out of antibiotic use in livestock for growth promotion will be essential for long-term AMR control. • Increased professional advice and vaccination of food animals can reduce the emergence and spread of drug-resistant infections.

5 World Bank (2019, 65–68) provides a detailed introduction to AMR.

Core SDGs	How AMR impedes progress on the SDG	How progress on the SDG helps to address AMR
3 GOOD HEALTH AND WELL-BEING	• Globally, drug-resistant diseases currently cause at least 700,000 deaths a year (IACG 2019). • AMR will increase treatment costs, making effective care unaffordable for many, and universal health care unattainable. • Emerging and increasing resistance to drugs to treat HIV, TB, and malaria is one of the key barriers to eliminating these diseases. Multi-drug-resistant TB alone is estimated to cause 230,000 deaths annually (IACG 2019). • Reducing child and infant mortality relies on effective antibiotics. Currently, 200,000 neonates die each year from drug-resistant infections, such as pneumonia or resistant bloodstream infections (Costello and Petersen 2016).	• Strategies to reduce the risks of AMR must be linked to improving care and ensuring access to effective care when needed. • Central to addressing AMR is ensuring that health systems are accessible and have a trained workforce providing evidence-based high-quality care in a hygienic setting (Tayler et al. 2019). • Increased vaccine coverage reduces the incidence of disease from resistant pathogens and limits the need for antibiotics; in turn, this prevents the development of AMR (WHO 2020c). • Falsified and poor-quality antibiotics contribute to AMR. Hence, improving access to high-quality antimicrobials and preventing falsified and substandard medicines from reaching the market will help to reduce AMR. • Reliance on out-of-pocket payment for health care correlates with AMR in LMICs (Alsan et al. 2015).
6 CLEAN WATER AND SANITATION	• Globally, 1 in 4 health care facilities have no access to basic water services, 1 in 10 have no sanitation services available, 1 in 3 do not have adequate facilities to clean hands at the point of care, and 1 in 3 do not segregate waste safely. Lack of basic WASH services is greatest in least-developed countries, where 50 percent of health care facilities lack access to water services and 60 percent have no sanitation services at all (WHO 2020c). • Lack of access to adequate WASH services is giving rise to the spread of infectious diseases; in turn, this increases antibiotic use and thus drives the emergence and spread of AMR.	• Each year, hundreds of millions of cases of diarrhea in humans are treated with antimicrobials. Universal access to WASH could reduce such cases by 60 percent (WHO, FAO, and WOAH 2020). • Improved WASH services are critical to reducing the spread of infection.

Core SDGs	How AMR impedes progress on the SDG	How progress on the SDG helps to address AMR
8 DECENT WORK AND ECONOMIC GROWTH	• By 2030, increased mortality and morbidity due to AMR, and thus reduced labor supply, could cause a decrease in global economic output of 1–3 percent, with estimated losses as high as US$3.1 trillion (World Bank 2017).	
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	• Antimicrobial compounds and their metabolites can be found in the wastewaters from manufacturing sites for medicines and active pharmaceutical ingredients. In extreme cases, antimicrobial compounds have been found in water downstream from manufacturing sites in concentrations higher than those found in the blood of patients taking medicines (WHO, FAO, and WOAH 2020).	• Effective pollution controls on pharmaceutical production, health facilities, and agricultural production will substantially decrease the risk of AMR emergence and spread in the environment.
17 PARTNERSHIPS FOR THE GOALS	• To effectively tackle AMR, collaboration and partnerships are needed across all relevant sectors (human, animal, plants, and the environment) and at all levels (national, regional, and global).	• Working in partnership means taking up the One Health approach to addressing AMR.

Related SDGs

5 GENDER EQUALITY	Women are more affected by AMR, resulting in gender inequality. For example, women's exposure to AMR and antimicrobial use is higher during pregnancy, childbirth, menstruation, and abortion. Women are also more likely than men to be unpaid caregivers, and their greater presence on the front lines of caregiving roles in health and education increases their vulnerability to AMR.	11 SUSTAINABLE CITIES AND COMMUNITIES	Addressing overcrowding, poor WASH provision, and inadequate regulation of basic services will decrease the risks of infections and hence the emergence and spread of AMR in cities.
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	Quality-assured local production of antimicrobials, vaccines, and diagnostics can improve access to medical technologies, and this is an important part of the strategy for some countries. Investment in R&D is vital for the development of vaccines, new antibiotics, and diagnostics.	13 CLIMATE ACTION	Global warming is resulting in changing patterns of disease and increased reliance on antimicrobials in non-immune populations. Taking action on climate change will decrease the likelihood of extreme weather events and the associated spread of resistance.

Related SDGs

10 REDUCED INEQUALITIES	AMR can lead to increasing inequalities within societies; also, certain groups may be particularly vulnerable to drug-resistant infections. These groups include women, children, migrants, refugees, people employed in certain sectors (e.g., agriculture or health care), and people living in poverty.	14 LIFE BELOW WATER	If countries develop aquaculture, appropriate regulation is essential to ensure access to high-quality antimicrobial agents and to minimize the overuse and misuse of antimicrobials.

Source: Adapted from WHO, FAO, and WOAH 2021.

Note: LMICs = low- and middle-income countries; SDG = Sustainable Development Goal; TB = tuberculosis; WASH = water, sanitation, and hygiene.

AMR has the potential to increase inequalities among society's vulnerable and marginalized groups, particularly women, who have a greater risk of experiencing both the direct and indirect consequences of AMR. Pregnancy and childbirth may put women at an increased risk of AMR infections, especially in settings with unsafe or unhygienic health care, inadequate water and sanitation, insufficient or unaffordable antimicrobials, or inadequate knowledge about appropriate medicine use. Gender norms and attitudes can also influence the prescribing practices of health care providers, and they can inform how individuals use antimicrobials (their patterns of compliance, consumption, and self-medication) and how they experience disease more generally (their access to health care and their health-seeking behavior) (ReAct 2020; WHO 2018). Furthermore, women and girls engage in caretaking activities more than their male counterparts; an increase in disease due to AMR stands to exacerbate this inequality, further reducing women's workforce participation and girls' schooling. In sum, women are at risk from AMR because of the processes associated with both sex (a biological factor) and gender (social factors) (WHO 2018). Ensuring effective and equitable impact on AMR requires acknowledging and understanding how women and men (as well as other groups in society) may face different risks and different levels of risk, and how they may be impacted by AMR and the efforts to address it (WHO 2018).

Other vulnerable groups, such as the elderly, men who have sex with men, and indigenous people, may face significant challenges owing to the rise of AMR. These populations often face unique circumstances that make them susceptible to the adverse effects of AMR. The elderly, who tend to have weakened immune systems and a higher likelihood of chronic illnesses, are more prone to infections that may require antimicrobial treatments (Giarratano et al. 2018). However, AMR limits the effectiveness of these treatments, rendering them less potent. Men who have sex with men and may be at a higher risk of sexually transmitted infections also face a significant burden: as AMR spreads, the ability to treat these infections may become compromised, leading to complications, increased transmission rates, and potential long-term health consequences (European Centre for Disease Prevention and Control 2023). Indigenous communities, often residing in remote and underprivileged areas, face multiple challenges in health care access. The emergence of AMR further exacerbates these difficulties, as limited resources and inadequate health care infrastructure can impede the ability of indigenous communities to address and manage resistant infections effectively. This situation heightens the vulnerability of these populations, as they face higher rates of infectious diseases and limited access to appropriate treatments (Doherty Institute 2019). Addressing AMR in vulnerable groups requires tailored strategies that consider their unique circumstances, including strengthening of health care systems, promotion of education and awareness, and efforts to ensure equitable access to appropriate antimicrobial therapies.

In meeting the challenge of AMR, the World Bank brings the comparative advantage of a multisectoral offering, built over many years, as well as the financial and technical resources to support clients in building systems that can safeguard the future of their citizens. The World Bank brings both a global reach and the ability to engage in all sectors that are relevant to addressing AMR (public health, animal health, food systems, environment, disaster risk management, global risk communications). As noted in the World Bank One Health Operational Framework, few development institutions can claim such a country-level track record of engagement through lending and economic work in all these sectors—and, moreover, a capacity for global scope in delivery (World Bank Group 2018). The World Bank has valuable operational expertise supporting multisectoral programs, from design to appraisal to implementation of substantial investments and related policies, and it has worked to improve coherence and coordination across sectors. The World Bank can finance and mobilize additional resources for these programs through its technical support and operations. In the past, the World Bank provided financial support to a bridging framework for national capacity assessment tools developed by the WHO and World Organisation for Animal Health (WOAH); it also supported the response to multiple recent Ebola outbreaks and mobilized the Global Program for Avian Influenza (GPAI). Furthermore, the World Bank has flagship operations currently addressing AMR. One example is the Regional Disease Surveillance Systems Enhancement (REDISSE) program in West Africa, which supports community-level surveillance systems and processes across the human and animal sectors, the development of interoperable surveillance and reporting systems, and the establishment and upgrading of laboratories, among other activities.

Higher-level objectives

Addressing AMR goes hand in hand with the attainment of universal health coverage (UHC) and with factors that contribute to good health, such as sustainable agriculture and food safety. UHC aims to ensure that people have access to the health services they need, when and where they need them, without financial hardship. UHC includes the full range of essential health services, from health promotion to disease prevention, treatment, rehabilitation, and palliative care.[6] In the absence of efficacious antimicrobials, it will become harder to treat many routine diseases without compromising people's financial health.

Addressing AMR and achieving UHC necessitate a systems-focused approach to improving health care (Tayler et al. 2019). Measures that support UHC, such as infection control and prevention interventions, training of health care workers, and provision of routine immunizations, can limit the scope for AMR by reducing the need for antibiotics. Addressing AMR is therefore intertwined with the attainment of UHC, as both aim to ensure that populations can appropriately use antibiotics when needed and that antimicrobials remain efficacious, timely, and cost-effective means of treating infection.

AMR is also intrinsically linked to strengthening of primary health care (PHC) and improving the readiness of health systems to prevent and respond to pandemics. Antibiotics can play a critical role in the cost-effective and swift treatment of diseases in PHC settings. Without the ability to draw on antibiotics, PHC costs—and unnecessary referrals to secondary and tertiary care—stand to increase. In the event of a pandemic, or indeed in managing the backlog of a pandemic, the loss of this vital everyday tool puts additional pressure on the health system; this could in turn compromise the resilience of the critical systems that sustain economies, society, and our everyday lives. Within the human health sector, AMR investments can be made more sustainable when they are tied to national health sector plans, strategies, and budgets. These could include national UHC, PHC, and health security plans.

6 World Health Organization, "Universal Health Coverage," https://www.who.int/health-topics/universal-health-coverage#tab=tab_1.

AMR also stands to have a significant impact on human capital because it will reduce the ability of health systems to expediently manage health conditions. Advancing human capital depends on ensuring that populations are able to live healthy lives and that children and adolescents can complete a full cycle of education in preparation for their productive lives. Twenty-two African countries have committed to advancing the human capital agenda. This commitment is focused on key targets for 2023, including increasing learning-adjusted years of school by 20 percent, from 4.94 to 5.88 years, and increasing the overall adult survival rate from 0.73 to 0.81.[7] Antimicrobials are critical to effective health systems that can treat diseases; when populations are able to mitigate everyday disease threats with ease, they can learn and support the growth of economies worldwide.

Beyond the health sector, addressing AMR goes hand in hand with improving the sustainability of food and agricultural systems and safeguarding the environment, which are also part of the human capital and SDG agendas. The efficacy of antimicrobials is important for the viability of animal production systems—both terrestrial and aquatic—as antimicrobials are an important part of ensuring animal welfare, efficient production, safe trade, and food and nutrition security.[8] Improving the prudent use of antimicrobials in livestock, aquaculture, and crop production is needed to safeguard these critical tools, which contribute to food security. Addressing antimicrobial use on farms helps limit environmental pollution and risks to food consumers.

Global, regional, and national issues

Sustaining the efficacy of antimicrobials, a global public good, requires tailored approaches at the local, national, and regional levels. World Bank operations provide financing at all three of these levels, and the World Bank recognizes the importance of the local, national, regional, and global perspectives for AMR. First, at the global level, several international references, standards, and regulations have been developed to promote the prudent use of antimicrobials. For example, guidelines from the Codex Task Force on AMR provide a science-based approach to assessing and managing the risks to human health associated with the presence of antimicrobial-resistant microorganisms in food and animal feed. Second, the fact that AMR is not bound by national borders means that national, regional, and global efforts should be connected so that they are additive to one another and maximize the use of scarce resources for AMR. Third, there are specific national and regional dynamics to AMR patterns, which must be understood to inform programming at all levels. In this context, regional mechanisms can play an important role in coordinating efforts to assess and manage risks and in implementing programs to stop the spread and emergence of AMR.

7 World Bank, "Africa Human Capital Plan: Powering Africa's Potential through Its People," https://thedocs.worldbank.org/en/doc/910151554987573474-0010022019/original/HCPAfricaScreeninEnglish.pdf.

8 Food and Agriculture Organization of the United Nations, "Antimicrobial Resistance and Our Food Systems: Challenges and Solutions," https://www.fao.org/3/i6106e/i6106e.pdf.

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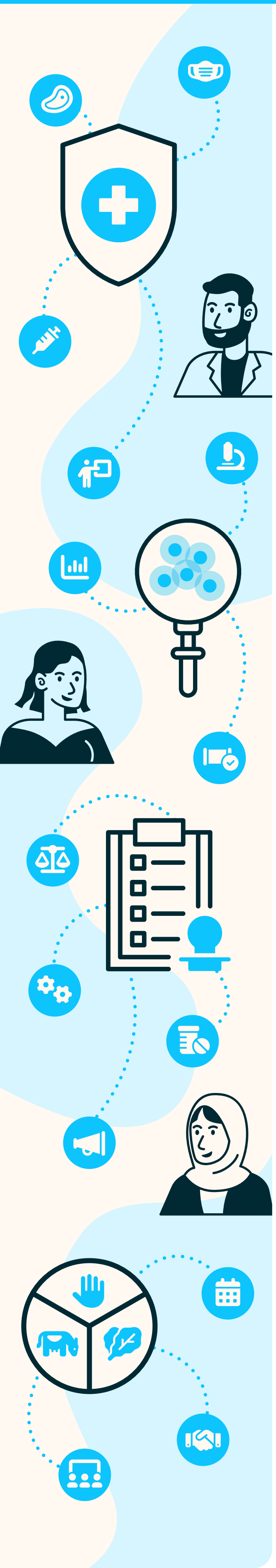
Chapter 2
Four Thematic Entry Points for Addressing AMR

A wide range of interventions across four thematic areas—reducing infections, strengthening monitoring and surveillance of antimicrobial resistance (AMR) and antimicrobial use (AMU), improving access and the rational use of antimicrobials, and strengthening sectoral and multisectoral coordination and governance—can help address the emergence and spread of AMR.



Chapter 2
Four Thematic Entry Points for Addressing AMR

Chapter 2 summary

A wide range of interventions across four thematic areas—reducing infections, strengthening monitoring and surveillance of antimicrobial resistance (AMR) and antimicrobial use (AMU), improving access and the rational use of antimicrobials, and strengthening sectoral and multisectoral coordination and governance—can help address the emergence and spread of AMR. This chapter describes a range of entry points that local, regional, and national policy makers and implementers can consider, across health, agriculture and food, and water and sanitation for implementing the AMR agenda across government.

Countries are at different states of readiness to address AMR, so that a comprehensive approach may not always be feasible; however, a broader vision of the range of options can help to maximize the effectiveness and sustainability of any given intervention. Some 170 countries have developed National Action Plans (NAPs); this large number suggests that in many settings there may be an appetite to make inroads across all four thematic areas. In instances where readiness is higher, and where a strong enabling environment and political consensus to address AMR are present, it will be relevant for governments to consider comprehensive programming across multiple areas and to choose from a range of options. In other settings, the appetite and funding to address AMR may be more limited, and programming may need to be more opportunistic and targeted. Nevertheless, across different states of readiness, a vision of the range of options remains important, as it offers a window to ensuring that financial and nonfinancial resources are utilized well and sustainably.

This chapter provides an overview of the four themes and discusses options to consider across sectors. AMR programs can typically be thought of in broad categories, i.e., stewardship, monitoring and surveillance, regulatory frameworks, and infection prevention and control (IPC). Understanding the general scope and rationale for each of these categories is important for designing effective programs. In general, all four will have to be in place in some fashion to adequately understand and address sources of AMR, though their scope and application will differ based on the country or regional context. Each of the categories involves more specific interventions and applications (selection of site, scale) that will have to be determined in each context.

Introduction

Efforts to address AMR can be optimized by adopting a systematic, well-planned, and coordinated approach across four thematic areas. These areas are reducing infections; strengthening monitoring and surveillance of AMR and AMU; improving the rational use of antimicrobials; and strengthening sectoral and multisectoral coordination and governance. Where possible, interventions and programming to address AMR are best pursued in concert with an overall focus on strengthening systems (e.g., for human health, animal health, environmental health, water and sanitation, agri-food) and their effective governance. This approach can reinforce entry points for prevention, detection, response, and recovery.

The programmatic areas and specific interventions examined promote general good practices; countries are at different baselines for implementing interventions that will shape the immediate feasibility, sequencing, and design of interventions. For example, in some settings regulatory and enforcement capacity will be feasible for central prescribing for human and/or animal use of antimicrobials; in other contexts, however, over-the-counter sales of antimicrobials are standard for a variety of reasons (e.g., infrastructure, workforce capacity, financial, access, etc.). Innovations can support countries' efforts to shift the baseline in novel ways—for example, using mobile pharmacy technology to support regulation, enforcement, and monitoring of antimicrobial prescribing and access.

The broad packages presented in this chapter draw on technical guidance from experts on how clients and teams can go about selecting interventions that build toward a coherent program to address AMR. Context-specific realities and funding constraints often require choosing some interventions over others; hence the importance of understanding how one intervention fits within a suite of options to ensure effective programming. Chapter 3 narrows this focus to specific interventions that can be supported through World Bank operations based on feasibility, key qualifiers, and other considerations to maximize potential for positive impact. Table 3, at the end of this chapter, provides a summary of interventions across four thematic entry points for addressing AMR in various key sectors.

Reducing infections: A focus on IPC, vaccination, and nutrition

Reducing the incidence of infections in humans and animals is key to addressing the rising burden of AMR (Berthe, Bali, and Batmanian 2022). Prevention is better than cure: by sustainably improving health, animal, and food production systems, it is possible to markedly reduce the demand for antibiotics, thereby reducing the selection pressure of known microorganisms, i.e., minimizing the occurrence of new resistant strains. The past two decades have been seminal in extending knowledge of the origin and emergence of novel diseases. Studies have recognized the importance of the interface between humans, domestic animals, and wild animals in the cross-species transmission of zoonotic diseases. Efforts to prevent and reduce the incidence of infections are the first line of defense against AMR, and each sector has a leadership role to play. This role is best advanced through the One Health approach (World Bank 2018).

Globally, several pathogens have been identified as of high concern for transmission in health care settings, based on the burden they cause and their resistance to first- and second-line antimicrobials (leaving only last-resort antimicrobials as options). Examples include *Escherichia coli* and *Klebsiella pneumoniae, methicillin-resistant Staphylococcus aureus* (MRSA), and *Clostridioides difficile (C. diff)* infections. Monitoring is essential to detect changing patterns and newly resistant infections and to enhance IPC measures as needed.

IPC seeks to reduce the risk of infections and limit spread of AMR. IPC programs in human health are typically focused on communities and health care facilities (in general and for highly infectious or highly susceptible patients), and they operate at national level (Storr et al. 2017). In hospital settings, IPC programs are critical for preventing and containing the spread of health care–acquired (or "nosocomial") infections in both patients and health care workers. Approximately 10 percent of patients globally develop one or more health care–acquired infections. Both high-income countries (HICs) and low- and middle-income countries (LMICs) face the challenge of health care–acquired infections, though rates of infection are highest in LMICs. These infections cause additional disease burden in already-sick patients (typically with disproportionate impact in intensive care or neonatal units), often requiring additional treatment and use of antimicrobials, and they have the potential to be drug-resistant and challenging to treat. Front-line health care providers play an essential role in IPC, as do sanitation workers, laundry services, hospital administration, and patients themselves. The staffing of trained professionals, often known as infection preventionists, helps maintain a focus on IPC in health care facilities.

National programs are focused on ensuring the enabling environment is in place to support implementation—for example, by developing guidance, improving awareness, assessing infrastructure needs to support IPC, and shaping education and training initiatives. Specific interventions under IPC programs often include hand hygiene and other water, sanitation, and hygiene (WASH) interventions, use of personal protective equipment, surface cleaning, waste management, injection safety, limits on invasive procedures and nonessential inpatient stays, and facility capacity limits to ensure sufficient patient spacing (Storr et al. 2017). Surveillance and monitoring play a key role in identifying clusters of health care–acquired infections and assessing efficacy of IPC interventions. Monitoring also helps to identify AMR patterns associated with the highest burden of disease, helping to target interventions. Several IPC good practice guidance documents have been established by the World Health Organization (WHO) and other agencies, based on existing evidence and expert input.

Conflict situations can make IPC in hospitals more challenging, for example, through damage to critical infrastructure, workforce shortages, overcrowding, and the interruption of supply chains and access to care (Lowe et al. 2021). These situations may exacerbate common barriers to effective IPC in low-resource setting. A study of 15 LMICs found that bundling IPC interventions, including with in-service training, ongoing performance feedback, and outcome and process surveillance, supported adherence to IPC protocols and yielded significant reductions in incidence of and deaths associated with central line infections (Rosenthal et al. 2010).

Just as IPC interventions are essential in human health, improved biosecurity measures are essential for a sustainable farming system. These biosecurity measures are procedures and structures aimed at reducing the probability of the introduction, establishment, survival, or spread of any potential pathogen to, within, or from a farm, operation, or geographical area (Huber et al. 2022; Caveney, Jones, and Ellis 2011). Internal biosecurity involves diminishing the spread of an infectious agent within a herd, while external biosecurity refers to preventing introduction of such agents into the herd or flock. These measures have several key components: good hygiene practices, i.e., hand washing and implementation of cleaning and disinfection routines; isolation of new animals or sick animals; limits on nonessential traffic on the farm; cleaning of materials entering the farm/premises to remove visible dirt; rodent control; and the use of an "all-in, all-out" approach to cleaning and disinfection between batches of animals. Surveillance and monitoring are important in identifying and reporting signs of infections and clusters on the farms.

The water sector can support the efforts referenced above—i.e., IPC and biosecurity—by improving safe drinking water infrastructure and access in communities, farms, and hospital settings, and by improving sanitation infrastructure to treat community and hospital sewage and other wastewater (see Box 4).[9] More broadly, concerted efforts are needed to enhance and expand waste management practices in agriculture and aquaculture production and processing. These efforts may include applying advanced water and waste treatment to destroy resistant genes, supporting infrastructure for closed water systems in aquaculture, and mitigating the effects of climate change that increase the incidence of infections by incorporating flood-proofing interventions and infrastructure.

Box 4. Combatting AMR through WASH and IPC in Health Care Settings: Key Data Points

Source: Joint Monitoring Programme (WHO, UNICEF, and WaterAid), www.washdata.org.

In health and agriculture, interventions and investments to scale up vaccinations in the general population and among animals remain central and are highly effective in preventing and curbing the spread of infectious diseases. The potential for vaccines to tackle infections and AMR is threefold: First, existing vaccines can prevent infections that would otherwise require antimicrobial medicines. Second, by reducing the prevalence of primary viral infections, which are often wrongly treated with antibiotics, vaccines can reduce antibiotic misuse and prevent secondary, potentially drug-resistant, bacterial co-infections. Third, the development and use of new or improved vaccines can prevent diseases that are becoming increasingly difficult to treat or untreatable due to AMR (Ginsburg and Klugman 2017; Mishra et al. 2012; Holm et al. 2022). For example, in human health, vaccines against *S. pneumoniae, Haemophilus influenza* type B (Hib), *Salmonella Typhi, Bordetella pertussis*, tuberculosis (TB), and *Neisseria meningitidis*, some of which are part of existing immunization programs, can prevent morbidity and mortality due these pathogens, including drug-resistant forms. There is increasing evidence on the positive impact of some these vaccines, i.e., for *S. pneumoniae* and *Hib* on resistant infections (WHO 2020b). Similarly, in animal health, antibacterial vaccines prevent infections that would otherwise require antibiotic treatment. For antiviral vaccines in animals, the positive effect on antimicrobial use is seen through prevention of viral diseases and the associated risk of bacterial co-infections (PACCARB 2019; WOAH 2015). The effects of vaccination in animals can deter the use of antimicrobials as growth promotors, which accounts for the largest proportion of global consumption and is a major driver of AMR.

9 Joint Monitoring Programme (WHO, UNICEF, and WaterAid), www.washdata.org.

Improved nutrition in humans and animals is additive to these preventative efforts because of its direct link to immune systems that are more robust against infections. Through various mechanisms, nutrition can be a vital determinant of infectious disease susceptibility and disease progression in both animals and humans. Undernutrition often reduces the development and effectiveness of immune responses essential in limiting and clearing infections. For example, in human health, death rates from acute respiratory infections, malaria, diarrhea, and measles are much higher in children who suffer undernutrition than in those who do not. Additionally, micronutrient deficiencies such as vitamin A deficiency have been linked to malaria morbidity and diarrhea severity in some populations; poor maternal nutrition and consequent impaired fetal growth are strongly linked to neonatal deaths from sepsis, pneumonia, and diarrhea (Black et al. 2008). In animal health, young animals such as piglets, broiler chickens, and calves are susceptible to diseases and disorders, leading farmers to increase use of antimicrobials. Animal nutrition strategies can support host defense systems and reduce the presence of pathogens and harmful substances such as mycotoxins in feed and water. Functional nutrition to promote animal health and reduce infections remains an important tool in decreasing the need for antimicrobials in animal production (Coen et al. 2021; Civitello et al. 2018).

Strengthening monitoring and surveillance of AMR and AMU

Monitoring and surveillance are a strategic priority under the WHO (2015) Global Action Plan on AMR. The two terms are often used interchangeably, though monitoring typically contributes to an overall surveillance system. Policy makers and actors in health, agriculture, water, and the environment need better insight into current and past AMR-related data to elucidate the mechanisms for acquiring new resistance, monitor existing cases, and anticipate future threats. Accelerated investments in better structures for collecting and consolidating data are needed, specifically in these critical areas: antibiotic consumption by humans and animals, resistance rates for available drugs, and research knowledge on the molecular foundations of AMR.

Global standards have been established for reporting on two areas of monitoring, which are collected via the Global Antimicrobial Resistance and Use Surveillance System (GLASS): (i) antibiotic consumption, and (ii) the presence or prevalence of antimicrobial-resistant pathogens, resistant genes, or antimicrobial residues. WHO GLASS proposes a master protocol (WHO 2020a) to be used for the generation of reliable estimates of mortality attributable to AMR bloodstream infections (BSIs), focused on the two AMR Sustainable Development Goal indicators.[10] Tracking consumption can monitor which antimicrobials are being used, in what quantities, and for what reasons, helping to target inappropriate or excess use (as well as underuse compared to indicated treatment) and guide stewardship campaigns. Tracking residues can be a proxy for consumption, helping to detect the uses and environmental dissemination of antimicrobials and the potential for exposures. Monitoring of resistant pathogens and genes provides information on evolutionary and epidemiological trends, such as detection of new strains or the spread in a population.

In general, the design of monitoring interventions comes down to matters of scope and scale, including the location of monitoring (e.g., hospitals, communities, farms), sample type (e.g., clinical, food products, water, soil), and the specific residues or pathogens to be screened. Other information may also be relevant for monitoring, such as the availability of counterfeit products at points along the supply chain, or the results of behavior assessments, using methods such as direct observation or knowledge, attitudes, and practice studies. Several specific applications of monitoring

10 United Nations Statistics Division, "SDG Indicators: Metadata Repository," https://unstats.un.org/sdgs/metadata?Text=&Goal=3&Target=3.d.

are examined in more detail in Chapter 3. In addition, it should be recognized that surveillance is key to inform development and measure effectiveness of all interventions listed in Chapter 3. It can serve a wide range of objectives, such as informing development, implementation, and monitoring and evaluation of national goals and policies to control AMR; informing IPC policies and interventions; informing antimicrobial treatment guidelines and antimicrobial stewardship; informing national Essential Medicines Lists and regulatory and procurement policies; and informing estimates of the burden of AMR (Pezzani et al. 2020).

While surveillance activities may be implemented by individual sectors, it is important that there be a mechanism in place for multisectoral integrated surveillance of AMR in line with a One Health approach (FAO 2020; Aenishaenslin et al. 2021). All sector actors need to be aligned and coordinated through a One Health platform on various activities contributing to the readiness and effective functioning of AMR surveillance systems. In health, agriculture, and water, these activities include accelerating investments in laboratory capacities, which involves expanding physical facilities and enhancing laboratory technician training for human, veterinary, and environmental science. These investments are poised to improve antibiotic susceptibility–driven clinical practice and pathogen or residue testing of food on import and other points in the market chain. For agriculture and health, more needs to be done to set up robust prescribing data systems and ensure integration and coordination. In agriculture, this effort is vital for monitoring risks and pharmaceutical use in the food system and for monitoring consumption adherence at regional, local, and farm levels. A similar joint effort is required to enhance waste and wastewater data systems in the water sector. Accelerating the maturity of these data systems will provide improved capacities to monitor AMR and residues in the effluent, e.g., at manufacturing sites, hospitals, and farms. In turn, actors will be able to set and monitor targets for resistance and residue levels in environmental sources.

Improving access and the rational use of antimicrobials: A focus on antimicrobial stewardship and regulatory frameworks

All antibiotic use, whether appropriate or not, can lead to the emergence of AMR. Unfortunately, inappropriate and excessive use of antibiotics is common in HICs and LMICs and in both human and animal sectors. Limiting inappropriate use of antibiotics is crucial to preserve the effectiveness of antibiotics for both human and veterinary medicine. This effort is well articulated in strategic objective 4 of the Global Action Plan on AMR, which aims to reduce the inappropriate use of antibiotics as an essential element of National Action Plans (WHO 2015). Notably, however, a large proportion of the world's population lacks access to effective antibiotics. LMICs are disproportionally affected; challenges in consistent and reliable access to antibiotics persist mainly due to affordability of antibiotics and inadequate domestic funding for health, leading to high out-of-pocket spending by patients, among other results. Efforts to increase access to antibiotics are crucial, but they need to be guided by the framework of rational use. Antibiotics should be viewed as a rapidly depleting resource that is a cornerstone of saving human lives. Additionally, in animals with certain diseases, antibiotics are crucial to ensuring survival, welfare, and productivity and reducing the spread of disease. Thus, rational use initiatives aim not always to reduce antibiotic use but to ensure that use is always appropriate.

Improving access to antimicrobials, including in LMICs, will also require exploring and implementing push and pull incentives that promote investment in research and development of antimicrobials. For example, according to WHO's annual review of antibacterial agents in clinical and preclinical development, the R&D pipeline for new antibacterial medicines is insufficient to tackle the challenge of increasing emergence and spread of antibiotic resistance (WHO 2022). Furthermore, while R&D capacities are skewed toward HICs, the general availability of and access to new and existing antibiotics, including generics, is a challenge for countries of all income levels.

This antimicrobial pipeline and access crisis requires innovative financing measures to improve the economic conditions for antimicrobial drug development.[11] These measures include global pooled efforts and stronger public-private partnerships to stimulate preclinical and clinical development of new antimicrobials and vaccines by closing existing gaps in funding. There is a need for accelerated efforts to ensure equitable access to antibiotics in LIMCs, which are currently facing the double challenge of having the highest AMR burden and lowest access to existing and new antimicrobials. Coordinated action is needed to develop and sustain a favorable market dynamic and create the financial incentives that are needed to drive antimicrobial R&D and innovation.

Antimicrobial stewardship (AMS) refers to initiatives that measure and improve how antibiotics are prescribed by clinicians and used by patients (US CDC 2018). AMS is considered one of the pillars of health system strengthening, along with infection prevention and control and patient medicine safety. Programs typically involve a set of coordinated interventions that may entail many components, including prescribing guidelines, training, audits (monitoring), and leadership commitments to ensure the necessary resources and political will are in place for implementation. While stewardship could be relevant for all settings where antimicrobials are used, many programs focus on hospitals, reflecting the relatively high levels of antimicrobial use and susceptibility of patients to clinically important infections. Monitoring of antimicrobial consumption as well as infections can help to guide stewardship actions. Notably, and in line with a comprehensive strategy for monitoring, stewardship interventions should also reflect the reality in LMICs, where the first point of care for most of the population is in communities through private clinics and community pharmacies. AMS in concert with other interventions (e.g., hospital hygiene, policies addressing overuse of antimicrobials) has been projected to save lives and costs—on the order of 1.6 million lives by 2050 and US$4.8 billion annually in Organisation for Economic Co-operation and Development countries (OECD 2018a, 2018b).

The WHO's Essential Medicines List AWaRe classifications provide global guidance on optimal use of a list of antimicrobials (WHO 2021a). The classifications place antimicrobials in three stewardship groups: those to access (antimicrobials with broad uses and relatively lower resistance potential that are recommended for first- or second-line treatment), those to *watch* (to be prioritized as key targets of stewardship programs), and those to *reserve* (save for last-resort use). At a national and local level, diagnostic and treatment protocols may be highly specific to the context—that is, may depend on the disease or procedure, availability of laboratory services, and adequacy of infection prevention measures. For example, stewardship initiatives may require that a bacterial culture test be performed to confirm infection to guide the prescription of antibiotics. In addition to antimicrobial resistance, stewardship often considers wider patient safety issues, such as medication allergies.

Prescribers, pharmacists, and nurses involved in the prescribing and administration of antimicrobials are typically important target audiences for hospital-based stewardship programs. Improved prescribing practices may also be dependent on access to laboratory services (for timely detection and diagnosis) and information technology to build prescribing protocols into staff workflows. Both inside and outside of health care settings, health care providers have an important role to play in educating patients on appropriate use of antimicrobials, such as adherence to treatment regimens. Suboptimal prescribing may reflect several factors, including overprescription (i.e., prescribing when not needed), selection of overly broad-spectrum antimicrobials, unnecessary combination of multiple antibiotics, wrong antimicrobial based on clinical indication, wrong dose, wrong interval of dosing, wrong route of administration, wrong duration of use, or delays in administration of the antimicrobial dose(s) (WHO 2019). These factors call for a more proactive role from professional organizations in health, agriculture, and environment sectors in steering AMS initiatives to promote best practice through evidence-based guidelines.

11 Meeting note from the Sixth Meeting of the Global Leaders Group on Antimicrobial Resistance. Bridgetown, Barbados. February 2023.

Several implementation challenges for stewardship programs have been described in LMIC settings (Cox et al. 2017), including barriers related to drug availability, cost of antimicrobials, resistance to change, and limited diagnostic capabilities (Rolfe et al. 2021). Core elements have been identified for health care facility stewardship programs in LMICs, including leadership commitment, accountability and responsibility, AMS actions, education and training, monitoring and surveillance, and reporting and feedback (WHO 2019). WHO has defined 12 core elements for supporting rational use of antimicrobials:[12] establishment of a multidisciplinary national body to coordinate policies on medicine use; use of clinical guidelines; development and use of national Essential Medicines Lists; establishment of drug and therapeutics committees in districts and hospitals; inclusion of problem-based pharmacotherapy training in undergraduate curricula; continuing in-service medical education as a licensure requirement; supervision, audit, and feedback; use of independent information on medicines; public education about medicines; avoidance of perverse financial incentives; use of appropriate and enforced regulation; and sufficient government expenditure to ensure availability of medicines and staff. Policy guidance has also been developed for an integrated and programmatic approach to national AMS activities (WHO 2021b).

In addition to human health care uses, animal and agricultural uses of antimicrobials have implications for stewardship, including for veterinarians and farmers. Responsible and prudent use is often stressed in these contexts (Ferreira et al. 2022; Góchez et al. 2019). Interventions in the agricultural settings that have implications for AMS include requiring a veterinary prescription when selling antimicrobials for use in animals, preventing the use of antimicrobials for growth promotion in the absence of risk analysis, phasing out antimicrobial use for growth promotion starting with the critically important antimicrobials, enforcing regulations (e.g., checking markets where antibiotics are being sold and checking use in feeds), banning the use of medically important human antimicrobials in animals, establishing a maximum residue limit (MRL) and withdrawal periods in food-producing animals per the World Organisation for Animal Health (WOAH) standards, and harmonizing and complying with international standards, such as Codex Alimentarius (FAO and WHO 2015). In the water and environment sector, this includes setting limits and effectively enforcing these limits on the pathogen and residual levels in drinking water, environmental sources, effluent from manufacturing, and waste materials (e.g., for use as fertilizer). It is also essential to focus on the demand side for comprehensiveness. Interventions to meet the increasing demand for antimicrobials should aim at improving public awareness through addressing disinformation, improving risk communication through community- and national-level public awareness campaigns, and conducting research on behavioral norms, practices, and expectations.

Regulations play an important enabling role in policy implementation by incentivizing or disincentivizing certain actions, including those related to antimicrobial production, distribution, use, and disposal (Ming, Puddle, and Wilson 2019). A range of agencies may set regulations relevant to antimicrobial production, sale, or use, such as those with oversight of clinical practice, food and drug safety, commerce, imports and manufacturing, or environmental management. Regulations may span a range of issues, such as licensing of new antimicrobials (or alternatives), prescriber qualification requirements versus over-the-counter sale of antimicrobials, limits on the types and amounts of antimicrobials that may be used for certain purposes (including agriculture and aquaculture), quality and labeling requirements, definition of withdrawal periods (periods between administration of medicines and the processing of the animal for food), and good manufacturing practices for the management of waste and wastewater from antimicrobial production facilities to avoid dissemination of antimicrobial residues into the environment. Enforcement of regulations is a key element that requires ongoing resourcing and can be informed by monitoring to assess compliance.

12 World Health Organization, "Promoting the Rational Use of Medicines," https://www.who.int/activities/promoting-rational-use-of-medicines.

Several technical organizations have developed guidelines that can be translated into national regulations, such as the WHO's guidelines on use of antimicrobials in food-producing animals, which aim to preserve the effectiveness of antimicrobials that are clinically important for human populations (WHO 2017). While regulations provide broad parameters around use, more specific use parameters will usually be determined by professional associations or hospitals as part of stewardship programs.

Strengthening sectoral and multisectoral coordination and governance

As the determinants of AMR are multisectoral, no single sector has the capacity to address AMR by itself; collective action through the One Health approach is needed to make progress. Such an approach means strengthening coordination through deliberate collaboration within and across sectors to promote the best possible outcomes for all. This can be achieved by setting up regular meetings with defined agendas with a feasible frequency. WHO's working paper on multisectoral coordination outlines ways in which countries can organize their systems and processes to achieve effective AMR action (WHO 2018). Countries can engage in horizontal collaboration, which involves working across different government departments and nongovernmental stakeholders, and vertical collaboration, which involves working from local to global levels across sectors and from practitioners to central-level policy makers in the sector. Horizontal collaboration can be supported through knowledge-sharing platforms such as multistakeholder forums. Experiences from a set of focal countries, such as Ethiopia, Kenya, the Philippines, and Thailand, point to four categories of tools and tactics that can facilitate the establishment and sustainability of multisectoral collaboration for AMR: political commitment, resources, governance mechanisms, and practical management.

Multisectoral communication, coordination, and collaboration, including through a One Health approach, can be beneficial to adequately identify sources of risk and set priorities. One Health approaches can be built into the design of programs—to promote information flow from separate initiatives, to design and undertake joint initiatives (such as joint surveillance or joint training to support stewardship), or to carry out monitoring and evaluation that considers the needs, resources, and entry points and relevant outcomes for different sectors (thereby broadening the co-benefits and minimizing the trade-offs). The creation of national AMR coordination mechanisms with clear cascades to the local level is an important macro-level intervention to improve collaboration. Recognizing the need for multisectoral coordination, the Food and Agriculture Organization of the United Nations (FAO), WOAH, United Nations Environment Programme (UNEP), and WHO have established a Strategic Framework for Collaboration on Antimicrobial Resistance, which will support joint action for a One Health approach (WHO et al. 2022).

Political commitment and leadership are essential elements in mobilizing and allocating resources appropriately toward AMR action. Inadequate resource allocation to address AMR continues to be a persistent issue as suggested by the 2021 TrACSS data, which showed that only 20 percent of the countries that had developed AMR NAPs had budgetary resources to support and monitor implementation. Experiential evidence shows that countries with AMR leadership at a senior enough level and with decision-making authority can make and sustain progress over time. The drivers for political commitment often include new and compelling data points related to AMR, AMR champions (persons with respect and authority to work across sectors and galvanize action), global and national advocacy movements, and international agreements such as the Global Action Plan on AMR, which was endorsed at the 68th World Health Assembly in May 2015. The appropriate allocation of resources is fundamental to build trust, strengthen skills and capacity, and secure joint commitment for sustained action on AMR. It is also important to articulate how AMR is relevant to specific sectors, and how addressing AMR contributes to individual sectors' strategic aims and priorities.

This creates an enabling environment that allows for clear and budgeted sector-specific AMR work plans that can be resourced through existing government channels or can leverage funds from development partners.

A well-resourced administrative governance structure for AMR at the level above implementing agencies is often required to provide strategic direction and oversight. However, it is important to note that these structures need to be tailored to country setting or context, as there is no one-size-fits-all approach to AMR governance mechanisms. The governance mechanisms should deliver both horizontal and vertical collaboration as discussed above, and the approach should allow for good communication and consultation to successfully cascade action to implementing agencies. Experience from a set of countries shows that governance mechanisms should consider mainstreaming AMR within existing programs to optimize resources—that is, the overall AMR plan should be adequately anchored in various strategic plans across sectors in human, animal, plant, and environmental health. A tiered governance structure can be helpful in differentiating functions across levels. At the top, a high-level multisectoral governing body sets the strategic direction and priorities, ensures coherence, and allocates resources appropriately. The bottom level includes operational units within ministries, civil society, and private sector partners whose main function is to implement interventions, such as those identified and listed in National Action Plans. There is broad consensus on a need to keep governance mechanisms simple and lean, as complex arrangements can quickly become unwieldy and a barrier to effective action (WHO 2018).

Lastly, sustaining multisectoral collaboration within the governing structure can be challenging, given that most of the activities will happen in parallel and within vertical programs of individual sectors. Monitoring and evaluation frameworks with timely feedback mechanisms can help track progress, keep collaborators engaged, promote good practice, and foster cross-learning. The next chapter narrows the broad focus on packages or themes, presented in this chapter, to specific intervention areas that can be supported through World Bank operations based on feasibility, key qualifiers such as the evidence base, and other considerations to maximize potential for positive impact across diverse settings.

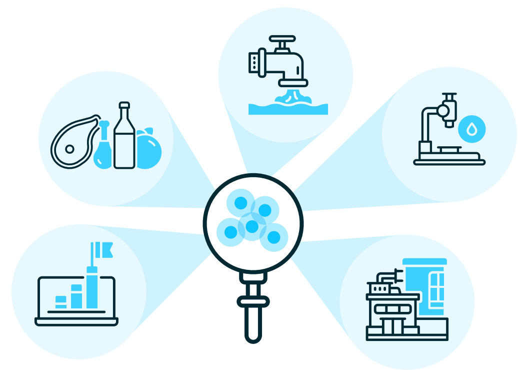
Four Thematic Entry Points for Addressing AMR

Theme 1

Reducing infections: A focus on IPC, vaccination, and nutrition

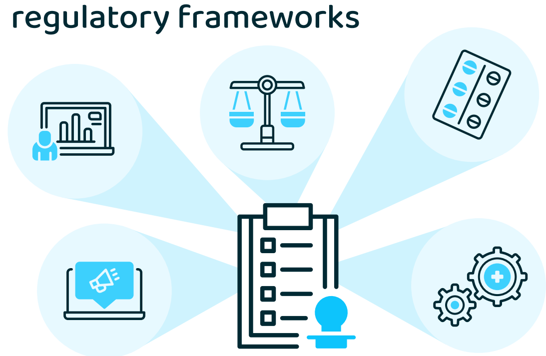
Theme 2

Strengthening monitoring and surveillance of AMR and AMU



Theme 3

Improving access and the rational use of antimicrobials: A focus on antimicrobial stewardship and regulatory frameworks



Theme 4

Strengthening sectoral and multisectoral coordination and governance

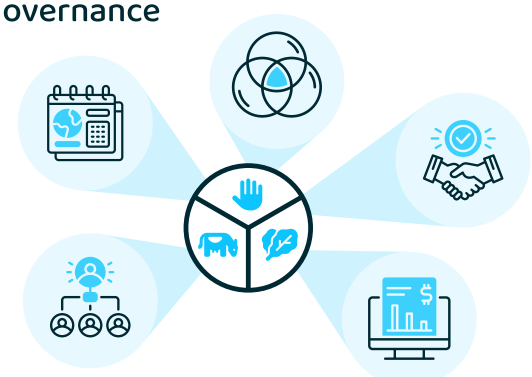


Table 3. Summary of Interventions across Four Thematic Entry Points for Addressing AMR in Key Sectors

Four Thematic Entry Points for Addressing AMR

Theme 1

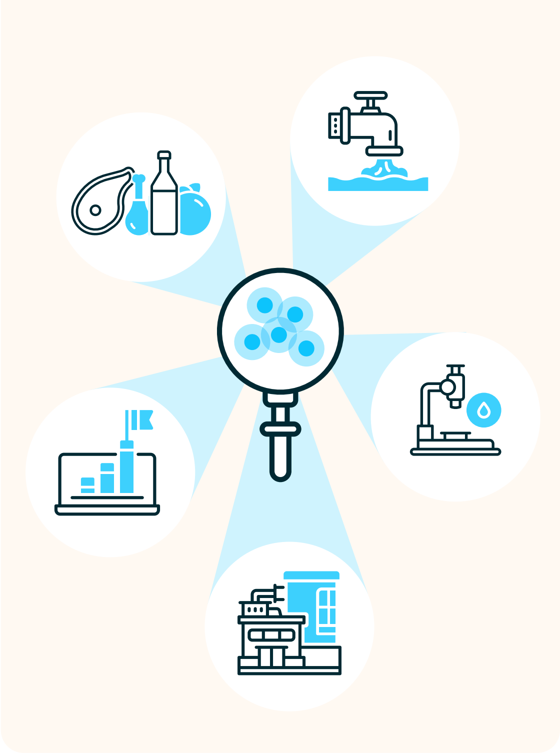
Reducing infections: A focus on IPC, vaccination, and nutrition

- Sustained training and education on general IPC and IPC for highly infectious patients for all health care workers
- Physical resources for health care facilities that optimize the reduction of infections, such as isolation rooms
- Public awareness campaigns on IPC
- Biosecurity and husbandry enhancements (e.g., quarantine, animal housing and spacing, improved nutrition, decontamination on farms)
- Farmer awareness campaigns on biosecurity and IPC
- Improved safe drinking water infrastructure/access in community and hospital settings
- Improved sanitation infrastructure to treat community and hospital sewage, other waste, and wastewater
- Waste management practices in clinical settings and in agricultural and aquaculture production/processing
- Application of advanced water and waste treatment to destroy resistance genes
- Closed water systems in aquaculture
- Flood-proofing infrastructure
- Scaling up of vaccination in the general population and in animals
- Improved nutrition in humans and animals given the direct link to robust immune systems

Theme 2

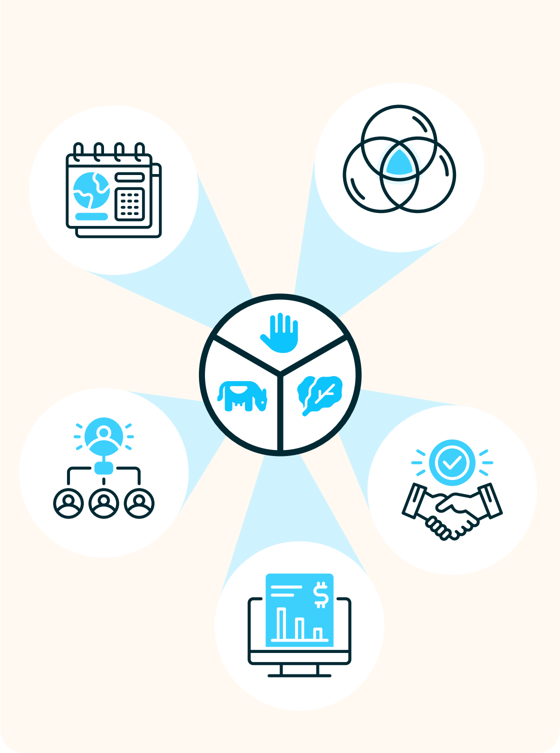
Strengthening monitoring and surveillance of AMR and AMU

- Acceleration of investments in laboratory capacities, such as expanding physical facilities and enhancing laboratory technician training for human, veterinary, and environmental science
- Robust prescribing data systems that are integrated and well coordinated
- Waste and wastewater monitoring data system
- Monitoring of risk and pharmaceutical use in the food system
- Pathogen and/or residue testing of foods on import and other points in the market chain
- Consumption and adherence monitoring at the regional, local, or farm level, and at the level of the individual veterinarian or other aquatic animal health professional
- Setting and monitoring against targets for reduction of use (e.g., by certain percentage or amount by weight of animals)
- AMR and residue monitoring in effluent (e.g., at manufacturing sites, at hospitals, at farms, etc.)
- Setting and monitoring of against targets for resistance and residue levels in environmental sources



Theme 3

Improving access and the rational use of antimicrobials: A focus on antimicrobial stewardship and regulatory frameworks



- Health care and animal health workforce training, such as pre-service training for professionals on AMR and rational use, continuous professional development on AMR and rational use
- Water management and sanitarian worker training on the interpretation of monitoring levels to guide water and waste treatment; appropriate disposal practices for antimicrobials
- Review of national clinical guidelines, protocols, and pathways to ensure rational use of antibiotics and introduction of algorithms and decision support tools to support adherence
- Improved public awareness through a focus on addressing disinformation, better risk communication, community- and national-level public awareness campaigns, and research, including on behavioral norms, practices, and expectations
- Quality improvement of antibiotic use within primary care: ensuring affordable, reliable, and sustainable access to first-line antibiotics where appropriate; improving access to diagnostics, especially microbiology and susceptibility testing
- Quality improvement of antibiotic use within secondary care: restrictions on use of certain antibiotics without infectious disease specialist/ microbiologist approval; improved access to diagnostics, especially microbiology (e.g., urine sample) and susceptibility testing; antimicrobial use review by pharmacists; microbiologist consultations for complex cases; review of hospital clinical pathways and protocols for rational use
- Exploration and implementation of push and pull incentives and other innovative financing measures that promote investment in R&D of antimicrobials
- Regulatory measures (such as banning the sale or dispensation of antibiotics without a prescription); enforcement mechanisms (such as checking markets where antibiotics are being sold); quality assurance and control of antimicrobial production (including generic production facilities); requiring a veterinary prescription when selling antimicrobials for use in animals; preventing the use of antimicrobials for growth promotion in the absence of a risk analysis; phasing out antimicrobial use for growth promotion starting with the critically important antimicrobials; enforcement of regulation (e.g., by checking for market sale of antibiotics, use in feeds); banning the use of medically important human antimicrobials in animals; establishing maximum residue limit (MRL) and withdrawal periods in food-producing animals per the WOAH standards; harmonizing and complying with international standards, such as Codex Alimentarius, specifically TFAMR

Theme 4

Strengthening sectoral and multisectoral coordination and governance

- Deliberate collaboration within and across sectors to achieve the best possible outcomes for all
- A One Health approach to multisectoral collaboration to enhance identification of risk and priority setting
- Political commitment and leadership at a senior enough level and with decision-making authority
- Mobilization and allocation of resources appropriately toward AMR action, i.e., by articulating clear and budgeted sector-specific AMR work plans that can be resourced through existing government channels or can leverage funds from development partners
- Well-resourced administrative governance structure for AMR tailored to country setting or context
- Monitoring and evaluation frameworks with timely feedback mechanisms

Source: World Bank.

Note: AMU = antimicrobial use; IPC = infection prevention and control; TFAMR = Ad Hoc Codex Intergovernmental Task Force on Antimicrobial Resistance; WOAH = World Organisation for Animal Health.

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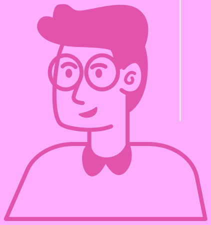
Chapter 3
Twenty Intervention Areas

While AMR is a multisectoral issue, sector-specific entry points are important for mobilizing prompt action… the driving forces behind AMR are shaped by actions in multiple sectors but each sector can and should do their part to address AMR.



Chapter 3
Twenty Intervention Areas

Chapter 3 summary

To facilitate better understanding (and funding) of interventions to address antimicrobial resistance (AMR), this chapter provides decision-makers and implementers with 20 intervention areas that can be supported through World Bank operations. The perceived complexity of AMR, lack of awareness about the steps that can be taken to address the issue, and insufficient financing have been identified as barriers to investing in relevant interventions. This chapter describes intervention areas of varying scope and scale that contribute to broader programming areas, as well as findings from a review of evidence to support task teams and clients. This list is not exhaustive or intended to imply that other interventions are not as valuable, but rather aims to provide a starting point for action.

While AMR is a multisectoral issue, sector-specific entry points are important for mobilizing prompt action. The driving forces behind AMR are shaped by actions in multiple sectors, but entry points for addressing AMR can be sector-specific. Several World Bank Global Practices—Health, Nutrition and Population (HNP), Agriculture and Food (AGF), Environment, Natural Resources and Blue Economy (ENB), and Water—and their relevant sectors can all play an important role, and their respective leadership is critical to ensuring that action is taken.

This chapter provides a review of the evidence for intervention areas and guidance on how to optimize investments within these areas across diverse settings. This current state of knowledge for each intervention are provided to orient practitioners to challenges and opportunities. Systematic reviews of the evidence on AMR interventions and conclusions on the widespread applicability of those interventions is limited, and this chapter is intended to provide guidance on the feasibility of interventions and key qualifiers and considerations to maximize the potential for positive impact.

Introduction

Addressing the significant threat of AMR requires improved awareness of AMR and the interventions that can be taken to address AMR's emergence and spread. The need for investments in interventions that protect global public goods and ensure no one is left behind in the fight against AMR was highlighted in the World Health Organization (WHO) Global Action Plan on AMR (WHO 2015), and successive Joint External Evaluations (JEEs) have highlighted financing as a constraint to addressing AMR in low- and middle-income countries (LMICs) (WHO 2018; Gupta et al. 2018). The goal of the Global Action Plan was that by 2017, all member states would have a National Action Plan (NAP) on AMR. Countries are in various stages of developing, budgeting, implementing, and evaluating NAPs; however, overall, operationalizing their NAPs remains a challenging process worldwide.

The challenge of developing and implementing NAPs is symptomatic of a broader political economy challenge facing AMR, but greater clarity about the steps that World Bank financing can support should allow more progress on AMR to be achieved. As noted by the Wellcome Trust (2020), the global activity and discussion surrounding AMR have been beneficial in raising awareness of critical issues that can all too easily be overlooked. But interest in AMR has not translated into broader implementation of initiatives, especially in LMICs, because AMR competes for attention and resources with other development priorities. This chapter addresses this limitation by highlighting interventions that are beneficial for AMR but that also contribute to the strengthening of the systems that are critical to addressing AMR, across human and animal health, water and sanitation, and the environment.

The purpose of this chapter is to provide World Bank teams and clients with a list of interventions that can guide the design of operations at the country and regional level. The intervention areas are aimed at preventing the emergence and spread of diseases and AMR. The evidence reviews examine the state of existing evidence to glean insights and guidance for the design of operations, while recognizing that a current lack of evidence does not indicate ineffectiveness. In some cases, the intervention has not been studied for AMR specifically, and thus the expected outcomes, challenges, and enabling factors cannot yet be fully determined. The intervention areas in this chapter are not definitive or exhaustive. Rather, they are intended to provide a starting point to support clients and World Bank teams in discussing, selecting, and shaping interventions. This chapter also provides guidance on how to draw on existing evidence to maximize the effectiveness of interventions.

This chapter discusses the drivers of AMR, discusses the evidence base for 20 intervention areas, and examines the feasibility of and considerations for implementing interventions in diverse settings. The chapter first provides the methodology for selecting the interventions for which an evidence review was conducted; Appendix 2 provides more details. The chapter then lists the intervention areas and discusses their relevance to various sectors and World Bank Global Practices. The last part of the chapter consists of 20 summary assessments, one for each intervention, including state of evidence, feasibility and enabling factors, knowledge gaps, multisectoral considerations, and considerations for optimizing implementation.

The intervention areas described in this chapter are broad and do not focus on specific disease management protocols (such as specialty and procedure-based clinical practices). Highly specific practices are not examined in this chapter as separate interventions since they fall under wider themes—e.g., prescribing, infection prevention and control (IPC)—and are dependent on the existing infrastructure, health care services offered, and provider training and practices aligned to a standard of care. However, project implementation efforts should seek out relevant evidence-based interventions and promote their adoption. The adoption of potential interventions should, where possible, be informed by evidence of effectiveness and feasibility, considering the range of implementation strategies and their associated enablers and barriers. This allows for translation and interpretation of findings and recommendations to relevant contexts (the settings and situations for potential implementation). The role and importance of implementation science and research cannot be overstated for facilitating the adaptation, adoption, integration, and scale-up of these interventions in different country contexts.

Methodology

To identify potential interventions and assess the weight of the evidence for possible AMR investment priorities, a global literature review was conducted. The literature review was structured into two stages. First, a long list of multisectoral interventions was developed and discussed among World Bank practitioners and external technical experts. Second, to learn more about the current state of evidence and implementation feasibility, the evidence base was reviewed for the 20 intervention areas that were prioritized for examination. The basis for developing the long list of multisectoral interventions was AMR "drivers," which provide a practical starting point for identifying major causal pathways or conditions creating AMR risk and impact. Interventions can be grouped in several ways, according to the type of intervention (structural, education, protocol), scale (individual, facility, national), primary sector(s), or other attributes.

In consultation with World Bank staff and external experts, 20 intervention areas were identified as important areas of focus for addressing major problems related to AMR emergence and spread. The evidence review takes a practical approach to assessing the current state of knowledge for each intervention area to orient practitioners to the challenges and opportunities for potential investments. A caveat is that the AMR landscape is evolving, and studies are in progress that can be expected to provide additional insights from more rigorous evaluation of interventions. A brief literature review was conducted for each intervention, bringing together findings from scientific and grey literature. Further details on the methods, such as key search terms, are provided in Appendix 2.

The reviews of each intervention area document the evidence for the interventions by their intent, rationale, and scope as well as their evidence base, current feasibility, gaps in knowledge, and key takeaways for investments. The approach explains to what extent the interventions have been proven effective, how the interventions have been implemented, and what factors have enabled or prevented successful implementation. This provides World Bank staff and clients with a tool to understand how the interventions are best optimized in a wide variety of project contexts and circumstances.[13]

13 Several factors shape relevance in a given setting. In the agriculture sector, for example, differences in climatic/ecological conditions and the type of agricultural production system can shape how antimicrobials are used and the ways that resistance arises, as well as how interventions are best implemented (for additional guidance about the specific livestock systems and agro-ecological contexts as defined by the World Bank, please see World Bank Group, "Theory Behind the ISL Guide," https://www.sustainablelivestockguide.org/theory.

Entry points for Global Practices and sectors for AMR interventions[14]

In countries of varying income levels, a set of interventions have been used in effective AMR programs across the HNP, AGF, Water, and ENB Global Practices (Table 4). These interventions are not equally effective or feasible in all settings, and prioritization of interventions as part of broader programs is especially important in resource-constrained environments. At the national, subnational, or regional level, intervention prioritization should be risk-based, reflecting estimated levels of risk and scale of impact to target resources. In general, AMR interventions related to surveillance, IPC, and animal husbandry have been found to be highly effective and broadly feasible in a variety of settings.

Sector-owned interventions play a critical role in addressing gaps and weaknesses that leave populations vulnerable to the threat and impact of AMR. Multisectoral action, drawing on the principles of One Health, can offer value addition in many cases, and coordination is required to identify how each sector can best contribute; however, multisectoral implementation can be challenging and can often face political challenges. Sector-specific interventions, ideally as part of well-coordinated multisectoral NAPs, can be more feasible in constrained environments and provide an important foundation for advancing toward multisectoral approaches that maximize scarce resources in the longer term. Thus, it remains important for each sector to understand the connections with other sectors so that single-sector interventions are positioned to enable multisectoral approaches and results. For a given intervention area, the relevant sectors may vary widely based on the distribution of mandates in a country, as well as the specific activities; the evidence review thus demonstrates how sectoral involvement could vary. For example, surveillance is examined under the health sector, but could also involve or be led by agriculture and environment; similarly, countering substandard and falsified (SF) antimicrobials could also be an intervention deployed through law enforcement agencies.

Multisectoral coordination and governance remains important; for example, quality monitoring of antimicrobial products, surveillance, and stewardship campaigns could serve, be leveraged by, or be taken up by multiple sectors. In fact, the effective implementation of high-priority interventions within the context of multisectoral NAPs requires a multisectoral governance framework or committee with the necessary leadership, mandate, resources, and accountability. Models like the Regional Disease Surveillance Systems Enhancement (REDISSE) project's human and animal health system strengthening provide proof of concept for addressing sector-specific operational and capacity needs while strengthening multisectoral coordination;[15] this coordination makes sense, for example, when considering common issues (such as procurement, supply chain, and access) that need to be addressed in both human and animal health systems. At the country level, One Health or multisectoral coordination platforms are an increasingly important resource for undertaking problem scoping and information sharing, and for optimizing project design, implementation, and evaluation to promote adequate and appropriate action. Therefore, strengthening collaboration within One Health or similar multisectoral coordination platforms is encouraged to support effective understanding of AMR risks and targeting and implementation of solutions, including the effectiveness of national action planning on AMR and related initiatives such as health security.

14 Information is presented for relevance to World Bank Global Practices; for this reason, information may be presented by sector, topic, or typical line ministry, depending on context.

15 World Bank, "Regional Disease Surveillance Systems Enhancement (REDISSE)," https://projects.worldbank.org/en/projects-operations/project-detail/P154807.

Table 4. Intervention Areas [16]

Health

1. Improving infection prevention and control in health care settings
2. Improving prescribing practices through guidelines for health care workers
3. Conducting public awareness campaigns
4. Increasing human health laboratory capacity and access to diagnostics
5. Strengthening surveillance of antimicrobial use (AMU) and AMR in human populations

Agriculture and food

6. Increasing oversight of AMU by veterinarians
7. Monitoring AMU, surveillance of AMR, and increasing oversight in plant/crop production
8. Improving animal husbandry practice and biosecurity
9. Monitoring sales and use of antimicrobials and surveillance of AMR in animals
10. Promoting behavior change campaigns in animal production
11. Increasing veterinary laboratory capacity and access to diagnostics

Water and environment

12. Improving infrastructure to provide access to water and sanitation in health care centers
13. Implementing effective treatment and disposal of sewage and wastewater
14. Improving waste management practices in agricultural and aquaculture production/processing
15. Improving safe disposal of unused antimicrobials
16. Monitoring presence of antimicrobial residues and antibiotic-resistant bacteria and genes in water and sanitation systems

Multisectoral

17. Detecting and deterring substandard and falsified antimicrobials (customs/law enforcement/health/agriculture)
18. Improving human and animal nutrition (health/agriculture)
19. Expanding vaccination coverage in humans and animals (health/agriculture)
20. Using closed water systems in aquaculture (agriculture/environment)

16 This table is identical to Table 1 in the executive summary.

Table 5 summarizes the evidence assessment for each of the intervention areas. Summary points are structured in terms of the state of evidence, feasibility, and key qualifiers or multisectoral considerations.

Table 5. Evidence Assessment for the Intervention Areas

Health sector

INTERVENTION	SYNTHESIS
1 Improving infection prevention and control in health care settings Jump to	Certain multidrug-resistant bacteria result in a high incidence and burden of disease from health care–acquired infections and are priorities for IPC in health care settings. IPC measures may encompass a wide set of interventions to help avoid preventable infections. This review examined the effects of IPC measures in human health care settings, including uptake of practices and the occurrence of resistant infections. **State of evidence:** There is strong evidence of effectiveness in both high-income countries (HICs) and LMICs, and of cost saving in particular in HICs. More research should be supported in LMICs. Implementation is still defective in many countries, in particular LMICs, and in primary health care settings. **Feasibility:** IPC interventions are mostly low in cost and feasible. However, implementation of IPC varies widely and requires sustained resource allocation and compliance for success. **Considerations:** Synergistic with water, sanitation, and hygiene (WASH), patient safety, quality improvement, health emergencies interventions.
2 Improving prescribing practices through guidelines for health care workers Jump to	Inappropriate prescribing of antimicrobials contributes to unnecessary AMU and potentially the development of AMR. Rational prescribing guidelines are key to counteract overprescribing and provide clinical guidance on prescribing the correct antimicrobial at the correct dose by the correct route for the correct duration. Studies were examined for the effect of prescribing guidelines on provider awareness, adherence to clinical guidelines, and infections. **State of evidence:** Evidence is limited in LMICs, but increasing buy-in for this approach indicates that the intervention is promising and has scope to decrease incorrect prescriptions. **Feasibility:** Feasibility is challenged by multiple prescribers (not just at point of care), limited access to diagnostics, chronic stockouts of both access and watch antimicrobials especially antibiotics, and poor enforcement of regulations related to over-the-counter antimicrobials. Logistics influence supply, which can affect access and ultimately prescribing practices.

INTERVENTION	SYNTHESIS
	Considerations: Likely to be complementary to demand-side reduction; requires addressing supply-side gaps to create enabling conditions, and may require implementation flexibility in some settings or work best initially for specific diseases. It is also important that national governments, regional bodies and community prescribers align with and utilise the WHO's AWaRe guidelines, ensuring that the key essential Access antibiotics are accessible and prescribed accordingly.
3 Conducting public awareness campaigns Jump to	The misuse and overuse of antimicrobials is driven in part by public perception. Targeting patient attitudes and perception of appropriate context for antimicrobial use will help combat further increases in resistance. This review looked at the effects of education and awareness campaigns for the general public on knowledge and prescribing practices. **State of evidence:** The evidence base shows wide variation in programs and mixed findings. Effectiveness has been demonstrated in a number of studies and across the income spectrum, particularly in terms of prescribing for respiratory infections. **Feasibility:** Generally feasible, though requires a baseline understanding of AMU practices and drivers of antimicrobial use, including perceptions, to target campaigns. **Considerations:** Appropriateness of campaigns will vary by baseline data on access to antimicrobials and AMUs.
4 Increasing human health laboratory capacity and access to diagnostics Jump to	Limited access to laboratory services, including diagnostics, hinders timely diagnosis and targeted treatment. Increasing laboratory capacity and rapid diagnostics to rapidly test patient samples could increase the likelihood of correct diagnosis, identify resistant pathogens, and lower the incidence of antimicrobial misuse. Studies on laboratory enhancement and access to diagnostics were reviewed for effects on prescribing and resistance. **State of evidence:** There is some evidence of effectiveness to inform appropriate prescribing of antimicrobials for select diseases, including in LMICs (for laboratory capacity, apparent benefits are more at the public health system level, whereas point-of-care diagnostics are more patient directed). Except in relation to select pathogens, diagnosis and antimicrobial prescribing generally remain imprecise in HICs and LMICs. For rapid diagnostics, there is an inadequate evidence base to assess effects on resistance-specific outcomes, though research protocols are in progress that will likely make the evidence base more robust.

INTERVENTION	SYNTHESIS
	Feasibility: Feasibility to inform prescribing relies on access (financial, physical) to routine laboratory consumables and rapid diagnostics, as well as integration into care provider workflows. While needs vary by context, broad screening approaches are not widely accessible at present. **Considerations:** Training and quality assurance are important enablers for success. Incentives are often not in place to support thorough diagnostic screening. Integration of point-of-care diagnostics should consider links to the broader surveillance system.
5 Strengthening surveillance of antimicrobial use (AMU) and AMR in human populations Jump to	Inadequate surveillance of AMU/antimicrobial consumption and AMR means that clinically important trends can be missed. Enhancing surveillance can enable an understanding of consumption trends, the early detection of resistant strains of public health importance, and the prompt notification and investigation of outbreaks. This review examined the effects of AMU and AMR surveillance programs on public health understanding and action. **State of evidence:** The link between antimicrobial resistance and use of antimicrobials is well documented. There is evidence of the effectiveness of AMU surveillance for prescribing patterns in both HICs and LMICs. There is strong evidence of the effectiveness of surveillance for AMR detection in all settings, though programs vary in scope and use. **Feasibility:** Broad feasibility, with data on antimicrobial sales already available, and data on antimicrobial use requiring a targeted approach. Quality and scale of information collection and utility for follow-up actions can depend on medicines legislation, data management infrastructure, and technical capacity (training on methodologies for monitoring antimicrobial consumption and use of data for action). The implementation of the Global Antimicrobial Resistance and Use Surveillance System (GLASS) in hospital settings has been successfully demonstrated in a variety of countries. The intervention area is adaptable to relevant context, but functionality requires information management systems and surveillance inputs (sampling, laboratory testing, etc.). **Considerations:** This intervention may be considered an anchor to inform selection of other interventions. Optimizing this intervention area requires multisource and multisectoral data coordination.

Agriculture and food sector

INTERVENTION	SYNTHESIS
6 Increasing oversight of antimicrobial use by veterinarians *Jump to*	Weak animal health systems often suffer from poor oversight of antimicrobial use. Regulators help ensure that veterinarians prescribe antimicrobials appropriately and only when necessary. Policies and programs on veterinary prescribing were reviewed for effects on AMU and appropriate prescribing. **State of evidence:** Strong evidence in high- and middle-income countries demonstrating effectiveness for reduction in AMU and resistant isolates in food-producing animals; poorly tested in low-income countries. **Feasibility:** Feasibility requires practitioner buy-in and awareness, and is likely to be constrained where veterinary services are weak (e.g., relatively limited access in rural compared to urban settings) and where antimicrobials are differentially regulated in feeds and as stock remedies. **Considerations:** Synergistic with monitoring and enforcement (otherwise, unlikely to be broadly effective), and may require reform of over-the-counter purchase of veterinary antimicrobials.
7 Monitoring of AMU, surveillance of AMR, and increasing oversight in plant/crop production *Jump to*	Inappropriate use of antimicrobials in plant/crop production can drive the development of AMR. Monitoring programs can improve understanding of usage trends and track the development of resistant strains to guide change in use and regulatory oversight. This review examined the evidence base on monitoring of AMU, surveillance of AMR, and regulatory oversight of AMU in crop production. **State of evidence:** Good evidence that AMU and AMR monitoring in crop production can detect meaningful scope and sources of AMR threats, whereas the effect of increased oversight is not clear—primarily because of few reported examples of regulatory changes, particularly in LMICs. **Feasibility:** Feasibility varies based on the scope and scale of monitoring, and may be challenged by weak agricultural sector governance (and resulting enforcement) and capacities and by lack of suitable alternatives. **Considerations:** May inform oversight needs, and may need to address farm-level awareness and use practices.

INTERVENTION	SYNTHESIS
8 **Improving animal husbandry practice and biosecurity** Jump to	Poor animal welfare and biosecurity conditions contribute to the incidence and prevalence of infections and subsequent antimicrobial use on farms. Improving husbandry practices and biosecurity conditions, including in animal production systems that are rapidly intensifying, could promote overall animal health and reduce the need for antimicrobials. Husbandry and biosecurity enhancements were reviewed for effects on AMU and animal health. **State of evidence:** Strong evidence in LMICs and HICs. Clear outcomes are reducing infections and AMU. **Feasibility:** Feasibility demonstrated by tailoring to different productive contexts and settings; may require more intensive or sustained intervention based on status of baseline supporting infrastructure. **Considerations:** May need to address farmer perceptions and comparatively low cost of antimicrobials as well as up-front costs to implement on farms.
9 **Monitoring of sales and use of antimicrobials and surveillance of AMR in animals** Jump to	The scale and scope of AMU and AMR in animals are generally poorly understood at national and subnational levels. AMU monitoring and AMR surveillance can improve understanding of current practices to guide targeted interventions that limit inappropriate use and detect changes over time. Studies on AMU monitoring and AMR surveillance were reviewed for effects on detection of usage patterns and changes in use practices. **State of evidence:** Strong evidence from HICs and to some extent LMICs that monitoring and surveillance can provide information about usage as well as possible stakeholders, intervention needs, and entry points, but data capture is uneven. **Feasibility:** Broad feasibility, though quality and scale of information collection and utility for follow-up actions will likely depend on veterinary legislation/enforcement, laboratory capacity (including availability of bacteriology services), and data management infrastructure and reporting systems. **Considerations:** This intervention may be considered an anchor to inform selection of other interventions and evaluate their effectiveness. For public health relevance, this intervention requires a One Health approach to integrate animal data with other information.

INTERVENTION	SYNTHESIS
10 Promoting behavior change campaigns in animal production Jump to	Animal production is a major driver of inappropriate antimicrobial use. Behavior change campaigns aimed at farmers and other animal production stakeholders target an important source of antimicrobial purchasing and administration. Studies on behavior change campaigns in farmers were reviewed for effects on knowledge and use. **State of evidence:** Promising reductions in AMU were seen in HICs, but evidence base is lacking in LMICs. **Feasibility:** Broad feasibility, though interventions will likely require general awareness around appropriate AMU practices first; may be challenging in settings with weak veterinary services. **Considerations:** Advisable in settings with sufficient alternatives to support reduced AMU.
11 Increasing veterinary laboratory capacity and access to diagnostics Jump to	Limited access to laboratory services, including diagnostics, hinders timely diagnosis and targeted treatment of animals. Increasing laboratory capacity and rapid diagnostics to test animal samples could increase the likelihood of correct diagnosis, identify resistant pathogens, and lower the incidence of antimicrobial misuse. Studies on laboratory enhancement and access to diagnostics were reviewed for effects on prescribing. **State of evidence:** Some promising early evidence from HICs on reduction of AMU for select diseases, but not yet for field-level treatment of disease in LMICs; utility for LMICs is likely for early detection as part of broader animal health surveillance. **Feasibility:** Feasibility is challenged by access to routine laboratory consumables, limited access/logistical challenges for diagnostics in rural areas where agriculture is often concentrated, and limited availability of field-ready and rapid diagnostics. **Considerations:** Complexities around farmer-veterinarian incentive structures may affect uptake of diagnostics.

Water and environment sector

INTERVENTION	SYNTHESIS
12 **Improving infrastructure to provide access to water and sanitation in health care centers** *Jump to*	Health care settings are a significant source of infections, particularly among patients with weakened immune systems. Increasing water and sanitation infrastructure in health care facilities as part of overall WASH enhancements is a priority for preventing initial infections and their spread—and the development of resistance—within facilities and to the broader community. This review examined the evidence on the effect of upgraded water and sanitation infrastructure in health care facilities on AMU, water quality, hand hygiene, and infection rates. **State of evidence:** Although WASH infrastructure in health care settings is a foundation for IPC, the evidence in relation to AMR-specific outcomes is mixed from both HIC and LMIC settings. Most studies to date report on cross-sectional findings or examine multiple interventions. **Feasibility:** In addition to up-front infrastructure, interventions require adequate water supply and continuous sanitation systems. Design must take into account points of contamination and monitoring and disinfection measures. **Considerations:** Synergistic with monitoring and system maintenance, as well as hand hygiene and other IPC measures.
13 **Implementing effective treatment and disposal of sewage and wastewater** *Jump to*	Untreated effluent can result in dissemination of residues or resistance into the environment, including drinking water sources. Advanced treatment technologies may help reduce the spread of antimicrobial residues, drug-resistant microorganisms, and antimicrobial-resistant genes (ARGs). This review examined the effects of advanced waste and wastewater treatment technologies on antimicrobial residues, resistant bacteria, and genes. **State of evidence:** Evidence for both conventional and advanced techniques demonstrates variable results for removal or reduction of resistant pathogens and genes. **Feasibility:** Many advanced (tertiary) methods appear experimental, with limited field deployment. There are several advanced treatments, which should be assessed separately. **Considerations:** Wastewater composition affects removal ability.
14 **Improving waste management practices in agricultural and aquaculture production/ processing** *Jump to*	Waste products from agriculture and aquaculture production and processing are potential sources of antimicrobial residues, resistant bacteria, and ARGs. Limiting the flows of wastewater, manure, and agricultural runoff containing antimicrobial residues, drug-resistant microorganisms, and ARGs helps limit the spread of resistance. Studies involving anaerobic digestion, composting of manure, and manure lagoons were reviewed for effects on residues and genes.

INTERVENTION	SYNTHESIS
	State of evidence: Appears to be effective for reduction of antimicrobial residues in a variety of settings, but inconsistent for antimicrobial-resistant genes. There is lower certainty in this assessment for aquaculture than for livestock production. **Feasibility:** Feasibility relies on waste containment and specialized requirements of technologies. **Considerations:** Technologies and their application to production systems vary, which provides some flexibility based on infrastructure.
15 **Improving safe disposal of unused antimicrobials** *Jump to*	Improper disposal can result in dissemination of antimicrobials into the environment via trash, sewage, or other waste, potentially contaminating water systems. Improved antimicrobial disposal practices may help to avoid water contamination. This review focused on the effects of safe medication disposal initiatives on awareness and utilization. **State of evidence:** Some evidence from HICs and LMICs for medicines in general (not just antimicrobials), but most point to limited uptake. **Feasibility:** Feasibility challenges relate to centralized collection, awareness, incentives, and responsibility for destruction, particularly where systems for proper disposal are lacking. **Considerations:** Programs vary in scope, frequency, geographic coverage, and longevity; a few long-standing take-back programs in HICs do report high rates of return of unused medicine.
16 **Monitoring presence of antimicrobial residues and antibiotic-resistant bacteria and genes in water and sanitation systems** *Jump to*	Contamination of water can result in dissemination of resistant bacteria and genes. Monitoring can generate data on the type of antimicrobials being detected in water and waste sources and on resistance patterns to guide epidemiological understanding and action. This review focused on effects of monitoring antimicrobials (via residues) and antimicrobial resistance in water and sanitation systems on detection and disease investigation. **State of evidence:** Effectiveness demonstrated from a range of settings to detect residues, drug-resistant microorganisms, and antibiotic-resistant genes (ARGs). **Feasibility:** Generally feasible, with standard technologies available in most settings. **Considerations:** Requires a One Health approach to put information from monitoring into context for risk determination and to inform risk management strategies.

Multisectoral

INTERVENTION	SYNTHESIS
17 Detecting and deterring substandard and falsified (SF) antimicrobials Jump to	SF antimicrobials include those that are counterfeit, degraded, mislabeled, or expired, and thus may be ineffective (or suboptimally effective) in treatment, prevention, or control of infections. Detection and deterrence mechanisms can play a role in ensuring the quality of antimicrobials to promote effective treatment for both humans and animals. Studies involving detection interventions were reviewed for effects on tracking, product quality, and legal outcomes (e.g., confiscation, prosecution). **State of evidence:** Evidence base comes from a range of settings, but evidence of effectiveness is mixed in low-income countries, with some promising findings for reduction of substandard and falsified products, including antimicrobials. **Feasibility:** Feasibility varies based on screening methods and quality and on scale of problem. **Considerations:** Likely requires accompanying enforcement and deterrence mechanisms, incentives for reporting, education/awareness, and alternatives to SF antimicrobials for success.
18 Improving human and animal nutrition Jump to	Nutrition status can affect susceptibility to infection and the severity and duration of disease in humans and animals, while some infections affect the body's ability to take up nutrients from food. Good nutrition can play a role in preventing infections and potentially reducing the need for antimicrobials and the subsequent selection pressure for resistance. Studies involving nutrition or food security improvements in humans and animals were reviewed for their effect on AMU or AMR. **State of evidence:** The evidence base is limited overall and focuses primarily on nutrient or probiotic supplementation. Reported findings are promising overall for effects on AMU. **Feasibility:** Likely to vary based on access. Nutrition interventions can vary widely among humans and in animal species, with specific goals that may or may not align with AMR-related objectives. **Considerations:** In animals, improved nutrition is often used in tandem with other interventions or to replace nonveterinary medical use of antimicrobials (i.e., for any other purpose than to treat, control, or prevent infectious diseases, such as weight gain). Interventions should also consider food safety implications.

INTERVENTION	SYNTHESIS
19 Expanding vaccination coverage in humans and animals *Jump to*	Infections can lead to AMU and the development of resistant pathogens. Vaccination provides individual protection and sometimes indirect effects to curb transmission of disease in humans and animals, reducing incidence of vaccine-preventable diseases, including several associated with high disease burden and antimicrobial use and the potential for development of resistant pathogens. Studies were reviewed for effects of vaccination on AMU and AMR in humans and animal populations. **State of evidence:** There is evidence in all settings, with promising (but in some cases mixed) results regarding AMU and some resistant pathogens. **Feasibility:** Requires infrastructure and resources for campaigns. Dependent on effectiveness against circulating strain(s), which can vary geographically. Some veterinary vaccines have safety challenges leading to narrow indications for use. **Considerations:** Existing vaccines are underutilized. Significance may vary based on AMR priorities and ability to target illnesses and syndromes with high AMU. Future vaccines may increase relevance for AMR outcomes specifically.
20 Using closed water systems in aquaculture *Jump to*	Effluent from aquaculture farms can be a source of environmental contamination, including the dispersion of antibiotic residues and resistant pathogens and genes through surface water. Recirculating water systems limit the flow of influent and effluent to and from the broader environment, playing a role in preventing the introduction and dissemination of contaminants that may be linked to resistance. Studies involving effects of closed aquaculture systems on AMR-related water treatment and water quality outcomes were reviewed. **State of evidence:** Studies of this intervention are limited to date in all settings. **Feasibility:** Dependent on aquaculture practices as well as infrastructure. Systems may vary widely. **Considerations:** May be relevant for biosecurity enhancements, particularly in certain aquaculture production systems or markets.

Source: World Bank

For the interventions listed in Table 5, the evidence base was generally limited in terms of effects related to AMR specifically. Because of the challenges of monitoring AMR or burden of disease from AMR as an endpoint, most studies focus on intermediate indicators or proxies (such as antimicrobial use). The interventions target many primary effects, which may or may not be directly indicative of effects related to AMR (for example, rapid diagnostics and ensuring sustainable access, leading to change in mortality or length of stay in a patient population would be inherently relevant for AMR, unless tracking something like health care–acquired resistant infections). Similarly, interventions were often implemented in concert; therefore, measurement cannot usually isolate the effects specifically from one component. More routine or increased monitoring will help to observe patterns that inform how the direction of AMR is changing.

Selecting appropriate indicators for monitoring and evaluating interventions related to AMR can pose challenges, primarily due to variations in the readiness of different countries to assess AMR and antimicrobial use systems. These variations extend to measuring additional outcomes, such as access to and the quality of medicines, and biosecurity in food production. In this context, the "Monitoring and Evaluation of the Global Action Plan on AMR" toolkit (WHO, FAO, and WOAH 2019) emerges as a reference standard for guiding the selection of core indicators. The toolkit strikes a crucial balance that allows global comparability while also accounting for unique contextual factors and data availability within countries. It provides a structured framework for countries seeking to align their monitoring and evaluation efforts with global standards, thereby fostering a more comprehensive and standardized approach to monitoring the emergence of resistance.

Overall, the evidence review provides a starting point to guide operations addressing AMR. The evidence reviews in this chapter provide a template that can be replicated for future intervention areas under consideration. They can help support the design of World Bank operations, increase awareness of potential challenges and realistic results to be expected, and guide selection and design of project components addressing AMR that can be applied across different settings and scales.

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Health sector

1 Improving infection prevention and control in health care settings

Improving IPC is an evidence-based approach to avoid preventable infections. It has relevance for humans, animals, environment, water, and sanitation; the human health care–relevant aspects are explored here. Globally, 1 in 10 patients gets an infection in the process of accessing care (WHO 2011). Certain multidrug-resistant pathogens (for example, *Klebsiella pneumoniae*) result in a high incidence and burden of disease from health care–acquired infections and are priorities for IPC in health care settings. IPC is recognized as a core component of patient and occupational safety in health care, contributing to quality of care. National and local applications can also support reduced exposure to animal and other disease hazards, as well as community-based spread. Often implemented with water, sanitation, and hygiene (WASH) measures, programs may include infection prevention experts, microbiology laboratory support, training, monitoring, built environment (e.g., ventilation), equipment, standard precautions, vaccination, decontamination, and personal protective equipment (WHO 2016). The review looked at effects of IPC measures in human health care settings on AMR, including uptake of practices and the occurrence of resistant infections.

IPC is a proven strategy in HIC and LMIC settings, with effectiveness demonstrated in avoiding or reducing pandemic spread, including for antimicrobial-resistant strains, and saving lives and money. In systematic reviews performed by WHO to support the global recommendations on IPC at the national and facility level, evidence of effectiveness was found for all eight core components of IPC; the highest number of studies demonstrated impact on health care–associated infection reduction, training and education, multi-modal IPC interventions, surveillance, appropriate staffing levels and bed occupancy, and built environment, materials, and equipment for IPC (Storr et al. 2017). A report by the Organisation for Economic Co-operation and Development (OECD 2018) showed that the most cost-saving interventions to limit the spread of antimicrobial resistance in health care were those aimed at improving hospital hygiene and antimicrobial stewardship (AMS), as these had the potential to prevent three out of four attributable deaths. It also showed that the increasing availability of IPC equipment and infrastructure (such as alcohol-based handrubs) at the point of care and isolation beds were associated with a proportionate reduction of the most common patterns of antimicrobial resistance that are associated with health care. However, effectiveness of IPC is hindered by the level of resources available and compliance challenges that affect uptake or sustainment. Notably, in several assessments, progress of IPC programs was shown to be significantly lower, and the frequency of infection and antimicrobial resistance significantly higher, in low- and middle-income countries compared to high-income countries (WHO 2022). Case studies from Israel, Sierra Leone, Tanzania, and Uganda are reviewed. In Israel, an aggressive IPC intervention in an intensive care unit saw a significant decrease in acquired Carbapenem-resistant *Acinetobacter baumannii* infections, and reduced colistin use after one year (Ben-Chetrit et al. 2018). These benefits extended into the wider hospital, likely linked to patients moving to other wards. A retrospective cost analysis at another Israeli hospital indicated a saving of US$200,000 when comparing the cost of isolation procedures, infection control specialists, and screening against averted cases of *methicillin-resistant S. aureus* (Chowers et al. 2015). In Sierra Leone, a post-Ebola study of IPC in a district hospital and peripheral health units found some rising compliance scores over a three-year period (screening and isolation, personal protective equipment, decontamination) and some decreasing scores (e.g., waste management, sharps safety) (Squire et al. 2021). IPC is also often paired with rational prescribing as part of overall stewardship.

In Tanzania, a joint IPC–antimicrobial stewardship program was shown to reduce surgical site infections following cesarean sections from 48 percent to 17 percent. While the intervention was associated with a reduction in gram-positive strains, an increase in gram-negative organisms—in some cases multidrug resistant—was also detected (Gentilotti et al. 2020v). These mixed findings reinforce the need for continuous monitoring with IPC. In Uganda, a One Health program on AMR involved training with human and animal health workers and schoolchildren, as well as a hospital-based Medicine and Therapeutics Committee that reviewed IPC guidelines. Participants reported use of enhanced practices after the program, including reductions in unnecessary antimicrobial prescribing (Musoke et al. 2020).

Feasibility varies based on the scope of IPC and existing infrastructure. A review on adherence barriers identified issues with supply volumes, insufficient space to isolate patients, and lack of training on guidelines (Houghton et al. 2020). Interventions should be sensitive to vulnerabilities (power disruption, flooding). As infections may be introduced by patients admitted to multiple facilities, data sharing on hospital–acquired infections among hospital networks is necessary (Tosas Auget et al. 2018). In addition to IPC within health care settings, pretreatment of waste emitted from these settings can also play a role in reducing environmental health impacts.

Knowledge gaps relate to marginal benefit of different options, as well as adequate incentives for organizational, social, and behavioral determinants of uptake and sustainment (Lacotte et al. 2020). Research gaps in the field of IPC were identified within the WHO guidelines of core components (WHO 2016), and research has been encouraged in these areas; a review of progress is underway.

Overall, IPC improvements have high potential to reduce preventable infections when compliance is sustained. IPC minimum requirements should be in place at national and health care facility levels to ensure minimal safety for patients, health workers, and visitors. This intervention is synergistic with prescribing guidelines and wider WASH interventions, and also informed by monitoring and surveillance that may indicate need for tailored interventions at the local level. Community-based IPC, as well as improved animal and environmental biosecurity, are other important entry points for IPC interventions. IPC should also be included in planning for climate-smart health systems.

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Health sector

2 Improving prescribing practices through guidelines for health care workers as part of antimicrobial stewardship programs

Prescribing guidelines help ensure that health care workers prescribe antimicrobials only when necessary and primarily provide the correct medication. Antimicrobials are a critical medical tool. The WHO has estimated that more than 50 percent of medicines prescribed, dispensed, and/or sold are done so inappropriately, and that half of all patients do not take their medication as prescribed (WHO 2004). Additionally, research has identified an association between antimicrobial prescription and perception of better medical care, creating a social platform for antimicrobial use to treat a range of diseases without rational clinical purpose and reinforcing the need for a shift in prescribing practices.[17] In concert with provider education and behavioral interventions, monitoring of antimicrobial use and use of diagnostics including algorithms, and in support of stewardship programs, rational prescribing guidelines can provide a tool to help counteract overprescribing and provide clinical guidance to ensure prescription of the correct antimicrobial at the correct dose by the correct route for the correct duration. Studies were examined for the effect of prescribing guidelines on provider awareness, adherence to clinical guidelines, and infections.

Such interventions are already underway in HICs but evidence is limited in LMICs; however, initial findings look promising. A systematic review of studies (n = 33) on antibiotic prescribing guideline adherence from 16 LMICs found that interventions and outcomes examined were highly varied, but most (85 percent) were multifaceted with several combined activities, and the majority indicated a beneficial effect, most commonly for clinical guideline adherence (Foxlee et al. 2021). As antimicrobial stewardship programs (ASPs) are most often carried out in the hospital setting, few programs have been addressing rational use in the community, where the bulk of antibiotics[18] are used, driving resistance. However, the use of multifaceted approaches was reinforced in a review of AMS interventions targeted to prescribers outside of hospitals (i.e., in community settings); the review found that education on updated clinical guidelines appeared to be an important component (Lam et al. 2021). Case studies are presented from Kenya, India, and West Africa. The Antibiotic Stewardship Program was created in six hospitals in Kenya and led by a group of physicians and scientists. The program follows an 18-month stepwise implementation strategy, which includes identification of the unique patterns of disease and resistance at each hospital, regular ward rounds, prescription audits and monitoring, staff education, and prescribing consultations (Gitaka et al. 2020). The program was ongoing at the time of review; however, the researchers published a nested qualitative analysis from three facilities, indicating that health managers in the institutions recognize AMR as a serious threat to health and support AMS interventions (Mbugua et al. 2020). A similar intervention in India (albeit on a smaller scale) focused on reducing surgical site infections by implementing an ASP focusing on both rational prophylaxis and treatment.

17 Changing practices may also require improving public awareness and cultural shifts to change patients' and providers' expectations (see for example "Improving public awareness campaigns" intervention review below). Prescribing guidelines are thus one tool that can be considered part of broader efforts to change prescribing practices. Practices related to over-the-counter sale of antimicrobials also need to be changed.

18 Antibiotics are a subset of critical tools for human medicine and thus are the focus of some studies (and antibiotic resistance is particularly important in terms of AMU and disease burden in health care settings specifically); however, other types of antimicrobials are also relevant for stewardship programs. In general, the focus of ASP is increasingly shifting to antimicrobials more broadly.

The study determined that an ASP using a collaborative approach is feasible to reduce surgical site infection incidence in the hospital and may be reproducible elsewhere (Sarang et al. 2020). In West Africa, researchers evaluated the efficacy of introducing a clinical decision support system—an electronic system to provide prescribers with rapid updated information and guidance on the correct antibiotic to prescribe based on input of symptoms and basic patient medical information. This intervention is currently in the early stages of implementation but has shown itself to be effective in decreasing incorrect prescriptions and eventually reducing AMR in those communities (Peiffer-Smadja et al. 2020). Programs such as Choosing Wisely, now rolled out in 20 countries including Brazil, involve a bottom-up approach to national guidelines based on input from prescribers (the program is currently not specific to antimicrobials) (Born and Levinson 2018).

Key issues are the use of antimicrobials when none are indicated and the use of inappropriate antimicrobials (e.g., using antimicrobials classified as watch by the AWaRe framework when one classified as access would suffice). Many HIC stewardship campaigns are rooted in rules on which members of the medical field are allowed to prescribe, whereas in some LMICs the scope of primary care and prescribing is wider (i.e., village doctor, pharmacists, midwives, etc.) and enforcement may be more limited. Due to the lack of AMU data, community-based AMS studies are difficult to perform in LMICs. Education and awareness are important enablers in all settings (Kunstler, Lennox, and Bragge 2019); computerized clinical decision support systems are a promising tool and can increasingly be accessed via smartphones to support behavioral interventions (Meeker et al. 2016). The limited availability of precise diagnostic information is a major bottleneck, and frequent stock-outs/shortages of antimicrobials may constrain implementation in some cases (Le Doare et al. 2015). The WHO (2021) Essential Medicines antibiotic book and the WHO AWaRe classifications provide global guidance but greater awareness by clinicians and translation into practice is needed, especially at subnational levels. Regular guideline updates and local adaptation of international guidance are needed, e.g., based on differences in the epidemiology of AMR. Surveillance and monitoring are needed to evaluate effectiveness of guidelines on an ongoing basis, with auditing and proactive feedback to providers in conjunction with training and other support. The broader workflow interaction with (or alternately, the distinction from) clinical decision-making algorithms, Standard Treatment Guidelines, and Essential Medicines Lists should also be examined.

Preliminary research and knowledge are lacking concerning where and how to design and implement guidelines given the range of resource availability, individual prescribing allocation, infrastructure, and sociocultural barriers. Baseline research and surveillance are needed to answer key questions: what type of infrastructure and resources are available, what are current trends in prescribing, what AMR disease is seen the most, what is the most frequent disease/symptom receiving antimicrobials, who is able to prescribe, and who is prescribing the most.

Prescribing guidelines are a foundation for prudent use in human medicine, but should allow for flexibility in implementation and be paired with demand-side reduction. To support implementation of the AWaRe framework, a draft handbook has been developed that aims to provide clinical guidance for the management of common infections appropriate for all settings, including guidance on the choice of treatment, dose, and duration (WHO 2021). When paired with training and other stewardship interventions, this type of intervention could be ideal for results-based financing projects.

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Health sector

3 Conducting public awareness campaigns

Increasing awareness and knowledge of the significant and negative impacts of AMR can help limit demand for antimicrobials where they are not relevant or appropriate. One of the main drivers of AMR is the misuse and overuse of antimicrobial medications. Current attitudes toward antimicrobials center around the belief that they are the gold standard in treatment, and that any illness, even if not treatable with antimicrobials, is best managed with antibiotics. The narrative on AMR has been too technical, limiting public understanding (Cars et al. 2021). Public awareness of the proper use and necessity of antimicrobials is a critical component in reducing the incidence of AMR and in slowing it. In LMICs, unique challenges in increasing public awareness and perception exist given the availability of medications through a range of formal and informal sources and self-medication. Targeting patient attitudes and perceptions of appropriate context for antimicrobial use will help combat further increases in resistance. Studies have reported an association between patient satisfaction and antibiotics prescription even when the medication should not have been prescribed. This review looked at the effects of education and awareness campaigns for the general public on knowledge and prescribing practices.

The evidence base reflects a heterogenous scope of approaches, and the evidence demonstrating effectiveness in changing awareness or prescribing outcomes is mixed, though some results are promising. A systematic review conducted by the RAND Corporation reported on a variety of educational interventions on change in awareness and practices related to antimicrobial use and awareness of antimicrobial resistance,[19] finding weak or inconsistent results from most (King et al. 2015). However, a subsequent systematic review on antibiotic prescribing for respiratory tract infections specifically (n = 14 studies) found communication campaigns to be highly effective (Cross, Tolfree, and Kipping 2017). Case studies from Thailand, the Czech Republic, and Arab Republic of Egypt are presented. Researchers conducted a study in Thailand to identify the population's current knowledge and awareness of antibiotic resistance by incorporating a module on antibiotic awareness into the 2017 Health and Welfare Survey (conducted by the National Statistical Office). This survey also included data on socioeconomic status, which created a comprehensive picture of the current awareness. Data collected from the module have been used to construct targeted strategies for public communication on antibiotic use and misuse (Tangcharoensathien et al. 2018). In the Czech Republic, the e-Bug teaching pack was rolled out in 2006 in elementary schools, with endorsement from the Ministry of Education (Heretova, Kostkova, and Benes 2011). An evaluation of e-Bug in the Czech Republic, England, and France found knowledge was significantly improved, though effect varied by region, and was still retained six weeks post-intervention (Lecky et al. 2010). However, it should be noted that knowledge does not necessarily equate to a change in behavior. While there is more limited study of prescribing or use outcomes among the public and prescribers, the population in Minya, Egypt, received messaging to raise awareness about rational prescribing. The study reported a 23.1 percent reduction in antimicrobial prescribing for acute respiratory infections (Kandeel et al. 2019).

19 Search terms used in the RAND Corporation's systematic review encompassed antibiotics and other antimicrobials; the majority of studies included in the analysis pertained to antibiotics (likely because of the relative focus in studies on antibiotics).

Feasibility is generally demonstrated but could be pursued in a range of different formats. The consensus across current literature reports high shares of low health literacy in LMICs, including lack of knowledge of antimicrobial misuse. To address public awareness, baseline data must be collected to determine the current state of knowledge so a targeted intervention can be implemented (Thornber et al. 2019; Chatterjee et al. 2020; Kosiyaporn et al. 2021). A campaign to increase awareness and knowledge may include a range of educational materials, such as distributed pamphlets, billboards, commercials, and school-based curriculums.

A key knowledge gap may relate to the utility of awareness campaigns in settings where antimicrobial access is limited, and campaigns may be a less prudent investment in settings with a weak enabling environment for prudent use (e.g., with insufficient antimicrobial alternatives, a lack of precise diagnostics, and poor prescribing practices). Additionally, there is poor understanding of whether awareness and behavior change are maintained over the long term.

This could be a more challenging intervention to mobilize in settings where the enabling environment is weaker, unless it is part of an upstream approach to address norms. To maximize the effectiveness of the intervention it would be advisable to consider the inclusion of education and training, awareness, and targeted messaging, as well as access factors (information, treatment, and diagnostics), ensuring inclusivity so vulnerable communities are reached in a beneficial way. When targeting prescribing practices, public awareness oriented at demand reduction appears to be more effective when combined with supply-focused interventions. Overall, any public outreach campaign requires sociocultural understanding and should be developed carefully with behavior change and communications experts.

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Health sector

4 Increasing human health laboratory capacity and access to diagnostics

Rapid detection and diagnosis can help health care workers determine the most effective treatment for patients and limit the use of antimicrobials where they are not needed; access to antimicrobial susceptibility testing can increase surveillance data. In resource-limited settings, clinicians often diagnose based on self-reported patient symptoms and a physical exam, which can cause misdiagnosis and lead to incorrect prescription. While access to timely, high-quality, and affordable diagnostics is a major gap in most low-income countries, this practice reflects norms also seen also in high- and middle-income countries and collectively drives overuse. Patients experiencing illness, such as a common cold, may be prescribed a broad-spectrum antibiotic even when not clinically necessary. Increasing laboratory capacity and rapid diagnostics to rapidly test patient samples could increase the likelihood of correct diagnosis and lower the incidence of antimicrobial misuse; and antimicrobial sensitivity testing (AST) will provide updated information to surveillance networks to monitor and report the levels of resistance. Studies on laboratory enhancement and access to point-of-care diagnostics were reviewed for effects on prescribing and resistance.

While increasing laboratory capacity generates many benefits, the current evidence points generally to broader public health system benefits versus individual patient diagnosis and change in AMU; for diagnostics, the breadth of accessible rapid/bedside tests is limited, and antimicrobial prescribing remains imprecise in HICs and LMICs. Outside of prescribing, the evidence base for this intervention was insufficient to assess effects on AMR endpoints.[20] There are some exceptions, including guidance of tuberculosis treatment. Examples are highlighted from Uganda, Pakistan, Vietnam, Malawi, Australia, and southern Africa. In Uganda researchers improved surveillance and laboratory capacity by leveraging an existing surveillance system to collect data on expanded causes of illness, facilitate real-time surveillance, and provide AMR data (Lamorde et al. 2018). In Pakistan researchers sought to identify gaps within limited-capacity laboratories to determine if AST is a feasible target. The study examined a cohort of five laboratories in which additional training and resources for AST were provided. It found that with close mentoring and support, AST is a feasible intervention to increase surveillance, and creating a laboratory network is a meaningful tool in decreasing AMR (Saeede et al. 2018). In Vietnam, work with microbiology laboratories found some patients were tested for antimicrobials not indicated, thereby wasting resources. The study found high vancomycin-resistant S. aureus rates from erroneous testing methods (Wertheim et al. 2013). Susceptibility testing guidelines were translated into Vietnamese and a collaboration was formed with an international reference laboratory for external quality assurance and confirmatory testing. At the point of care, most testing enhancements correspond to pathogen-based versus broad screening. For the latter, one such laboratory-based intervention is using patient-specific procalcitonin (PCT) biomarker levels to guide prescribing (Rhee 2016). Several studies have evaluated the potential for PCT-based guidelines on antibiotic prescription rates generally, and find that antibiotic prescribing in patients was enhanced (e.g., more accurate diagnosis, shorter course) for patients with severe pancreatic infection and sepsis (Sager et al. 2017).

20 It should be noted that several research protocols were published in recent years announcing studies that will shed more light on the effects of point-of-care diagnostics in relation to AMR (though most appear to be focused on prescribing practices rather than clinical outcomes).

While malaria rapid diagnostic tests are now widely used in malaria-endemic settings, a study of febrile patients (n = 25,486) in Malawi found that nearly 70 percent had non-malaria febrile illness; although there was high antibiotic prescribing, the lack of available tests to confirm diagnoses hindered determination of whether prescribing was appropriate (Kapito-Tembo et al. 2020). In Australia, a survey of general practitioners (n = 386) found that only 18.4 percent used point-of-care diagnostics for influenza or pharyngitis as part of antimicrobial stewardship programs, despite reportedly good access to rapid diagnostic tests in the country (Saha et al. 2020). In terms of cost, a multisite tuberculosis study in South Africa, Tanzania, Zambia, and Zimbabwe (n = 1,502 patients) found use of the Xpert platform (an automated, cartridge-based test platform) for TB detection was cheaper in a central laboratory setting than in primary care facilities; however, compared to point-of-care microscopy, facility-based use of the Xpert platform was likely cost-effective when willingness to pay is US$3,820 per treatment completion. (While resistant strain detection was not examined in the study, the Xpert platform does support resistance screening; the authors discussed how point-of-care access could support faster determination of drug-resistant TB and thus potentially increase cost-effectiveness, noting the potential trade-off of more false positives compared to microscopy) (Pooran et al. 2019).

The key for success of this intervention is reliable access to routine laboratory consumables and rapid screening tools fit to their specific contexts. It should be packaged with training, equipment, resource needs, supply chain management, and ongoing external quality assurance. Implementation of PCT and other broad screening technologies (e.g., multiplex PCR [polymerase chain reaction]) for diagnosis may not be feasible in many areas without access to testing infrastructure (primarily equipment and maintenance, electricity, reagents, trained personnel, and informatics support for interpretation) (Bunduki et al. 2019; Turner et al. 2021). At present, most available technologies are cost-prohibitive for high-volume, point-of-care testing, though some express screening tools (e.g., cartridge-based molecular diagnostic machines for specific pathogens) reduce time and workforce barriers in health care facilities. Depending on the country, the availability of over-the-counter antibiotics would make this intervention alone unusable and ineffective. Training and feedback may enhance effectiveness, given that test sensitivity and specificity vary. Other targets to increase laboratory capacity must prioritize core functions such as automated blood cultures and urine testing protocols for accuracy of diagnosis. For diagnostics (including rapid and point-of-care diagnostics), there are two separate needs: increasing access to existing diagnostics and investing in new ones. Even when rapid screening equipment is available in health care settings, use may be focused on specific pathogens (e.g., tuberculosis, COVID-19), with limited ability to screen for other pathogens (Okeke et al. 2020). Meaningful point-of-care tests may depend on the context and include detection of specific pathogens[21] (as well as co-infections), determination of viral versus bacterial infections, and antimicrobial susceptibility testing to support prescribing, among other indicators. Pipelines for validation, field testing, and regulatory approval processes for availability of point-of-care diagnostics—as well as price subsidies for affordability, distribution channels, workflow integration, and provider engagement to ensure their access and uptake—should be considered as crucial enabling factors (Sharma et al. 2021). Integration of point-of-care diagnostics should consider links to the broader surveillance system to ensure reporting is maintained.

21 Point-of-care testing needs are also likely to vary widely by setting (for example, to support diagnosis or rule out endemic infections that patients commonly present with in primary health care centers or pharmacies, versus detection of health care–acquired infections from ESKAPE pathogens).

Low willingness (and ability) to pay for diagnostics in comparison to antimicrobials presents a gap in knowledge about how to incentivize use of diagnostic screening. Poor baseline understanding of bacterial, viral, or protozoal infections raises some uncertainty for diagnostics and treatment. One starting point can be exploring ways to make access to diagnostics and their maintenance cheaper and easier to procure in LMICs. Innovations for low-cost point-of-care diagnostics and aggregating volumes to decrease costs stand to become increasingly important in this regard. Provider perceptions have been found to be mixed about the accuracy of rapid tests (Saliba-Gustafsson et al. 2021), but it is not known to what extent this may affect their uptake or utility.

Laboratory capacity has high utility for AMR, but relies on a trained workforce, reliable supply chain, and appropriate external quality assurance; point-of-care diagnostics are currently a partial but incomplete solution to support precise prescribing. Investments may vary, from enhancing current systems to establishing new national or regional laboratory systems. Making access to point-of-care diagnostics and their maintenance cheaper in LMICs—with the necessary breadth of testing scope for each context—will be key to support clinical decision-making. In addition to informing clinical practice, laboratory strengthening and diagnostics are important components of AMR surveillance and prescribing guidelines.

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Health sector

5 Strengthening surveillance of AMU and AMR in human populations

Surveillance of AMU and AMR enables an understanding of consumption trends, the early detection of resistant strains of public health importance, and the prompt notification and investigation of outbreaks. There are many possible purposes of surveillance systems and uses for the information they generate. Associations between the level of AMU (particularly related to misuse and overuse) and the development of AMR are well established (WHO 2018). Surveillance of antimicrobial use enables the early detection of inappropriate use and/or poor access to antimicrobials and supports the interventions for optimal prescribing and access to antimicrobials. AMR surveillance is a multitiered approach that includes tracking the emergence and increase or decline of resistant strains, and categorizing which strains remain susceptible. Such data will allow authorities to quickly respond to urgent threats, create targeted interventions based on triage of communities at highest risk, evaluate the efficacy of interventions, and provide clinicians with up-to-date prescribing guidelines to ensure real-time rational prescribing. Evidence was reviewed on the effect of AMU (captured by consumption—sales—and reported uses) and AMR surveillance on public health understanding and action.

There is strong evidence of the effectiveness of surveillance for AMR in hospital settings at all income levels; while surveillance interventions vary in scope and breadth, they point to the utility of data for treatment guidelines, outbreak investigations, and early warning of escalating trends. A review of AMU surveillance in 65 countries from 2016 to 2018, reflecting early implementation of a standard methodology on consumption monitoring, analyzed antimicrobial use by the AWaRe classifications for essential medicines and reported total and population-adjusted consumption (WHO 2018). The analysis indicated variation in the reporting of data disaggregated by hospital or community-level consumption, and demonstrated that consumption data can be sourced from a variety of stakeholders, such as wholesalers and importers. Case studies for AMR surveillance are presented from Vietnam, Israel, Republic of Korea, Brazil, Uganda, and India. The Viet Nam Antimicrobial Resistance (VINARES) initiative involves hospital self-reporting on use, infection control, and antimicrobial susceptibility, with feedback provided to benchmark against other facilities (Vu et al. 2019). In Israel, surveillance reports detected an outbreak of carbapenem-resistant Enterobacterales in hospitals, with genomic analysis identifying the source strain. This information led to hospital-based actions and monitoring, and ultimately a 10-fold decrease in transmission in acute care settings (and subsequent detection of other antimicrobial strains in post-acute care settings introduced from other countries) (Schwaber and Carmelli 2014). In 2015 the WHO implemented the Global Antimicrobial Resistance Surveillance and Use System (GLASS). Each country is responsible for the communication and sharing of data to build a global resistance network, which in 2021 was expanded to include reporting on consumption. In Korea, a modified version (with added bacterial species and antimicrobials) was created called Kor-GLASS. Kor-GLASS is based on the principles of representativeness, specialization, harmonization, and localization, via a network of eight sentinel hospitals (Liu et al. 2019). Brazil's national AMR surveillance system, BR-GLASS, was established in 2018; an analysis of the first year of the program examined data from three hospital microbiology labs representing patients from 301 cities. A total of 200,874 antimicrobial susceptibility tests were conducted from 11,347 isolates, yielding estimates of the number of hospital-acquired infections compared to community-acquired infections and identifying important trends, including the most prevalent pathogens, associations with specimen types, and antimicrobial susceptibility and resistance profiles of pathogens (Pillonetto et al. 2021).

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In Africa, Uganda was the first country to implement a GLASS system, first reporting in 2016 and subsequently benchmarking resistance prevalence findings against other countries in the region to support interpretation (Nabadda et al. 2021). In India, the Council of Medical Research developed a tool called i-AMRSS, which creates a network of institutions of varying capacity and medical specialties to collect AMR data and establish real-time reports (Kaur et al. 2014; Walia et al. 2019).

In addition to the traditional surveillance approach used by most existing national AMR surveillance systems, which is based on data collection through routine clinical sampling of patients, application of complementary strategies—such as national surveys to improve quality, completeness, and representativeness of data—should be promoted. Comprehensive data collection is required to obtain a complete picture of AMU and AMR, whether in a hospital or country (Gandra et al. 2020). Actual use is more precise than sales data, but requires more resource-intensive downscaling of surveillance to the point of use. Important features of surveillance are the tools used for data collection, management, and analysis, including standard operation procedures for sample collection and quality assurance in testing strategies. As many countries already struggle with health management information systems for reporting on routine diseases, particularly at facility level, data management training, infrastructure, and incentives may influence reporting effort. A multisectoral surveillance approach is critical to monitor consumption, emerging resistance, and susceptibility trends. To implement an effective surveillance network, country data must be collected from various institutions (including public health, veterinary services, and environment and water) and from laboratories; this will help create a standardized central hub where resistance and relevant prescribing data are reported and can efficiently support international reporting. In health care settings, supporting the clinician-laboratory interface is important to ensure that samples are sent for microbiology testing, and that results can be translated into practice in ways that account for key constraints (e.g., antimicrobial stock-outs). The time needed to strengthen AMR surveillance, and the degree to which it can be improved, depend on the functionality, infrastructure, and capacity of the human, animal, and environmental health and laboratory systems as well as the available resources.

Knowledge gaps related to AMR ecology and epidemiology mean that there may be challenges in putting surveillance findings into context. Further investigation may be needed to determine sources of risk, and to differentiate between baseline incidence (including background levels of resistance in nature) and changing trends. In these cases, use of more sophisticated (and costly) technologies such as genomic sequencing can be valuable. In addition, in the case of some reporting systems, the impact of falsified or mislabeled antimicrobials on the reliability and interpretation of consumption data is unclear.

Surveillance is a foundation of public health systems and of AMU and AMR detection and quantification, and is a relevant intervention for all settings. However, the scale and scope may require modification and planning to align with or leverage (and not disrupt) other priority surveillance programs, such as HIV and TB AMR surveillance, and to inform follow-up action as needed, such as stewardship policies (Pezzani et al. 2020). Needed modification can be supported by linking data from surveillance of AMR and AMU within regular health facility audits to monitor "quality of health care services" whether in primary, secondary, or tertiary care. This step will enable different medical specialties to work together and use surveillance data for action. Overall, ways to strengthen AMR surveillance include strengthening laboratory capacities; strengthening epidemiological data management and IT capacities; investing in development of hospital/health information systems; and implementing complementary surveillance strategies such as national prevalence surveys (which can also help to address the knowledge gap on impact of AMR on human health, including attributable mortality due to AMR, and assess the extra health care costs due to AMR).

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Agriculture and food sector

6 Increasing oversight of antimicrobial use by veterinarians

Prescribing algorithms and guidelines help ensure that veterinarians prescribe antimicrobials appropriately and only when necessary.[22] In situations where animal health systems are weak, this oversight also entails developing viable alternatives so that farmers can transition away from a reliance on antimicrobials. Prudent use guidelines may vary widely in scope, intended audience, and issuer (government, professional association, facility). Th absence of national animal prescribing guidelines has been reported; filling this gap can potentially contribute to the overall capacity strengthening and good governance of veterinary services and the veterinary workforce. Policies and programs on veterinary prescribing were reviewed for effects on AMU, appropriate prescribing, and AMR.

Pre-and-post studies of veterinary prescribing vary in scope, but some indicate promising trends. Case studies are presented from the Netherlands, China, the US, Tanzania, and Singapore. A systematic review with a total of 181 studies examined restricted use of antimicrobials in food-producing animals, with a mix of interventions (external restrictions, organic classification, self-labeled antibiotic-free, and voluntary restriction). A meta-analysis of a subset of the data (n = 81 studies) found strong evidence that restricted use of antimicrobials in food-producing animals was associated with a lower prevalence of resistant isolates in animals (reductions of 10–15 percent); a reduction was also observed for humans among farm workers and their contacts (Tang et al. 2017). After a rise in antimicrobial use, the Netherlands instituted compulsory and voluntary regulations in 2007, with a 56 percent decrease in use in farm animals by 2012 (Speksnijder et al. 2015). In China, regulations introduced in 2014 requiring prescription for veterinary use helped to reverse rising use trends in food-producing animals, which falling antibiotic prices had incentivized (Wu 2019). A study of swine veterinarians (n = 42) in the US on the effect of the Veterinary Feed Directive, which prohibited use of medically important antibiotics for growth pro¬motion, found most participated in training on the directive and shared information with client farms (Rademacher, Pudenz, and Schulz 2019). Over half of the veterinarians' clients phased out AMU for growth promotion altogether, and use of vaccinations, non-antibiotic feed additives, improved biosecurity, and improved nutrition all increased. However, restrictions alone are insufficient; a 2014 study of antimicrobial use in poultry production in Tanzania found prohibited antimicrobials available at veterinary stores and on farms, indicating the need for both expanded residue monitoring in poultry products beyond approved drugs and heightened enforcement at retail outlets (Mubito et al. 2014). A study of aquaculture producers in Singapore, where farmers can purchase antimicrobials freely, found that oversight by the Agri-Food and Veterinary Authority, including regular farm visits and sampling, was one deterrent factor for AMU, along with standards imposed by exporters (Lim et al. 2020).

22 Appropriate use prescribing reflects two key components: determining if antimicrobial therapy is warranted (when to prescribe) and, if prescribing is warranted, ensuring appropriate/prudent prescribing in terms of antimicrobial choice (narrowest spectrum informed by microbiological investigation/diagnostic stewardship), dose, route, and dosing frequency and duration.

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Feasibility depends on a strong veterinary authority, enforcement of regulations, or buy-in from veterinary practitioners. A review of national-level regulations on AMU in animals in Asia indicated key implementation gaps, among them continued use of antibiotics for growth promotion, and poor consideration of research on alternatives (Goutard et al. 2017). Some studies report mixed results, demonstrating occurrence of intended changes, such as a shift from third- to first-line antibiotics, but also an increase in other AMU, reinforcing the need for pretesting, training, monitoring, and refinement. Illegal online sale of veterinary antibiotics from several continents is a challenge (Garcia et al. 2020). The jurisdiction under which animal feed belongs (e.g., in regard to antibiotics in feed for growth promotion) is often not clear, with fragmented authority across agencies.

There are gaps in knowledge about efficacy and reach of veterinary prescribing regulations where sale of antimicrobials directly to farmers is common practice and access to veterinary services is limited. Socioeconomic factors must be considered when tackling the self-administration of antimicrobials by farmers (Chauhan et al. 2018). Studies in HICs continue to report pressure to prescribe antimicrobials and owner unwillingness to pursue diagnostics to help target AMU. In LMICs, dual registration of antimicrobials (with some available only by prescription from veterinarians and others freely available as stock remedies) can mean that availability bypasses prescribing practices in some cases.

Investments in veterinary prescribing should also involve reform of over-the-counter purchase of antimicrobials where relevant. Tailoring may be needed for certain classes of antimicrobials. For the success of this intervention, there is a wider need for overall animal health system strengthening, including a strong veterinary regulatory authority, monitoring, ability to reach the multiple channels typically in place for prescribing or purchasing of antimicrobials for animal use, and improved animal owner practices.

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Agriculture and food sector

7 Monitoring of antimicrobial use, surveillance of antimicrobial resistance, and increasing oversight in plant/crop production

Antimicrobials are in some cases used for the prevention and treatment of plant/crop diseases, particularly fungal and bacterial diseases that can cause major production losses and associated economic damage. The use of streptomycin, oxytetracycline, copper-based products, and some fungicides has been associated with resistance in plant pathogens, and while most plant pathogens are not considered a disease threat to humans, some (such as *Aspergillus* species) are increasingly recognized as causing human infections through food production and consumption (Miller, Ferreira, and LeJeune 2022). Mixed crop-livestock systems and their intensification add a layer of complexity in terms of antimicrobial use and links to the development and spread of resistance. Two linked aspects of interventions should be considered: addressing inappropriate AMU in cropping systems, and the monitoring and surveillance of the type of issues that arise from inappropriate AMU. This review examined the evidence base on monitoring of AMU and AMR and use patterns and regulatory oversight of AMU in plant/crop production.

Overall, the evidence base suggests that AMU and AMR monitoring in plant/crop production can detect meaningful scope and sources of AMR threats, whereas the effect of increased oversight is not clear—primarily because there are few reported examples of regulatory changes, particularly in LMICs. Monitoring interventions varied widely in their scope. Three case studies are reviewed, from Tanzania, the Netherlands, and Denmark. In Tanzania, a study documented imported and registered antimicrobials used in crop production and classified the uses and sources of antimicrobial introduction via literature review and stakeholder consultation (Mdegela et al. 2021). In the Netherlands, azole-resistant *Aspergillus fumigatus* was found in plant waste containing azole residues (Zhang et al. 2021). In Denmark, integrated pest management has been reported to help limit fungicide use in crops, resulting in lower usage than in the UK, Germany, and France; decision support during the crop season is facilitated through factors such as a disease monitoring network and use control thresholds (Jørgensen et al. 2008).

Feasibility varies based on the scope and scale of monitoring. Depending on the goals and baseline knowledge, qualitative studies can be useful for examining the types of antimicrobials used, including by specific production systems and farms. Linking use data to AMR outcomes, including via screening for residues and pathogens, requires access to laboratory infrastructure. Plant/crop monitoring cannot typically distinguish potential sources of antimicrobial contamination, such as direct spraying versus application of manure-based fertilizer (genomic methods may help pinpoint sources of resistance, but are resource-intensive). For oversight, feasibility may be challenged by a weak agricultural sector, especially where enforcement of agricultural practices is limited, awareness of antimicrobial or pesticide resistance is limited overall (e.g., Rahaman, Islam, and Jahan 2018), and the right incentives (e.g., compensation to farmers for losses) are not in place. A major challenge to feasibility is the lack of suitable alternatives, given potential trade-offs for plant/crop production in phasing out use and given challenges in registering new products (Lucas, Hawkins, and Fraaije 2015).

For oversight of use, knowledge gaps include the relative effectiveness of voluntary versus mandatory regulations, especially in connection with limited availability of suitable alternatives and varying enforcement levels. Optimal training, including on general cropping and other plant production good practices, and behavior change incentives at the level of the production system and individual farm also need to be articulated for AMR relevance. For monitoring, the direct epidemiological relevance of detection of residues and AMR in plants/crops for human health is poorly understood even for the currently limited set of plant pathogens of concern. While there is extensive focus on plant/crop resistance to disease and pests, much of this research is still experimental and targeted to genetic determinants, with only limited evaluation of responses related to disease and pest management activities (e.g. Tabashnik and Carrière 2019).

Monitoring in plant/crop production can help clarify the scope of use and possible relevance for AMR, and may inform areas of focus for potential oversight changes. Another relevant scope for consideration will be farm-level awareness and use practices, including availability and demand for alternatives to antimicrobials of concern. In addition to direct AMR threats to human health, plant pathogen resistance can lead to other important outcomes that require separate review, such as effects on food production volumes and ultimately food security.

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Agriculture and food sector

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Improving animal husbandry and biosecurity practices

Good biosecurity and animal husbandry at farm level will reduce the risk of infections and ensure healthier animals, thereby limiting the need for treatment. Underinvestment in biosecurity is recognized as a major contributor to the incidence and prevalence of infections and subsequent antimicrobial use on farms. Improving husbandry practices and biosecurity conditions, including in animal production systems that are rapidly intensifying, may promote overall animal health, reduce the need for antimicrobials, and help reduce occupational exposures by farm workers. Husbandry and biosecurity enhancements were reviewed for effects on AMU and animal health.

Animal husbandry and biosecurity interventions overall appear highly effective in improving animal health and reducing antimicrobial use; the evidence base is strong on the benefits across income settings. Case studies are reviewed from Vietnam, Switzerland, and the UK. In Vietnam, a three-year intervention provided small-scale chicken farms with regular veterinary advice on flock health and husbandry and antimicrobial replacement products. It found that antimicrobial use decreased by 66 percent, bodyweight increased, and weekly mortality fell from the intervention (Phu et al. 2021). In Italy, a study on improving welfare standards and biosecurity on beef cattle farms found a reduction in antimicrobial use associated with improved welfare (Diana et al. 2020). The “outdoor veal calf” model tested in Switzerland involving vaccination, a three-week quarantine, open-air housing, and health screening checks resulted in five times lower use of antimicrobials compared to control farms (Moser et al. 2020). A study in the UK points to the ability to improve early warning for potential disease events, such as via change in feeding behavior indicative of animal health status (Duthie et al. 2021).

Overall, husbandry enhancements appear feasible with some limitations, particularly when adapted to specific context and productive settings. Farm management practices pursued as a foundation for animal health, or in some cases as direct alternative(s) to antimicrobials, vary widely across different settings and production systems, with some innovative but overall low-technology approaches available. Baseline biosecurity, farm education, environmental determinants of contamination, and other factors will likely vary widely, though needs and opportunities for biosecurity and welfare improvements are reported from a range of HICs and LMICs. However, there are some key limitations; the low cost of antimicrobials (e.g., ~2 percent of farm production costs from a study of pig farmers in Vietnam) provides low incentive to invest in alternate risk management strategies (Coyne et al. 2020). Additionally, perceptions about the need for widespread use of antimicrobials for farm production could limit willingness, and some alternatives (e.g., zinc oxide) have other detrimental effects. Multiyear guided support and external resourcing appear to be beneficial for implementation. While this review focuses on biosecurity at the farm level, the movement of animals between locations (e.g., for rearing, veterinary, or trade purposes) demonstrates the need to share information on health care–acquired and other infections in animals.

Gaps in knowledge include willingness to pay or willingness to accept husbandry interventions, as well as an appropriate source of guidance for design and implementation support in settings where the capacity of veterinary services is weak. There are also questions around necessary supporting infrastructure (e.g., farmer education) and sustainment of biosecurity over time, particularly with changes in livestock industries.

This intervention can be financed in LMIC and HIC settings when tailored to local conditions, production systems, scales, and needs for accompanying education, infrastructure, and incentives. Building in husbandry and biosecurity from the onset as requisite for livestock investments may help to reduce AMU upstream in animal production systems. As part of biosecurity enhancements, worker education could include a focus on awareness around the costs of occupational exposures to antimicrobials to reinforce the importance of uptake.

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Agriculture and food sector

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9 Monitoring of sales and use of antimicrobials and surveillance of AMR in animals

Monitoring sales and use patterns and conducting AMR surveillance in animals supports more targeted interventions to limit or restrict improper antimicrobial use, including around critically important molecules or growth promoters. Antimicrobials in animals are used to treat, control, or prevent disease or increase weight. The scale and scope of AMU in animals is poorly understood at national and subnational levels, though AMU is known to be widespread and increasing with intensification of production systems. This situation can make it difficult to differentiate excess or inappropriate use from judicious (legitimate) use and adherence to guidance or regulations. It also limits understanding of the role of animal AMU in dissemination and human outcomes, and it results in a lack of baseline information for intervention comparisons. Antimicrobial sales and use data (e.g., class, volume, purpose, setting, and dosing) can improve understanding of current practices to guide targeted interventions and detect changes over time. Studies on AMU monitoring and surveillance of AMR in animals were reviewed for effects on detection of usage patterns and changes in use practices.

Overall, there is strong evidence that animal antimicrobial use monitoring and AMR surveillance provide useful information to identify AMR concerns and target interventions, though data capture is uneven and major gaps remain. Monitoring systems are in place in most European and North American countries, and AMU studies have been conducted in a variety of settings. Outside of Europe, most studies appear to be research-based versus reporting through a routine national or subnational monitoring system. Surveillance programs for AMR in animals occur across country income levels but vary in their scope and scale, such as long-term studies versus studies conducted at one point in time. Case studies are presented from Denmark, Cameroon, Thailand, the United States, China, and Brazil and the UK. Denmark launched its Integrated Antimicrobial Resistance Monitoring and Research Programme in 1995 (Dibner and Richards 2005). Patterns observed vary, from specific uses (e.g., respiratory disorders), to seasonal trends in use, to animal daily doses. In Denmark, the VetStat database tracked veterinary prescribing practices under its “yellow card” system and observed a 25 percent decline in per-pig use between 2009 and 2011 (Jensen et al. 2014). In Cameroon, import and livestock biomass data were used to analyze veterinary AMU in food-producing animals between 2014 and 2019. The study estimated total consumption, an increase in use of 104 percent over the time period, and identified substantial overlap with the WHO AWaRe categories for *critically important*, *reserve*, and *watch* antimicrobials (Mouiche et al. 2020). In Thailand, a study was conducted to analyze distribution of antibiotics; it found that in addition to farm households, approximately 30,000 individuals involved in animal feed imports, feed mills and stores, and animal health facilities were relevant to distribution of antibiotics and other medicines for animal use (Sommanustweechai et al. 2018). In the United States, samples collected from diseased pigs were screened for resistance at a state veterinary diagnostic laboratory between 2006 and 2016 as part of a continuous surveillance study; changes were found in AMR patterns over the time frame (Hayer et al. 2020). In China, data reported to the China Surveillance on Antimicrobial Resistance of Animal Origin database indicated that the prevalence of colistin-resistant *E. coli* in pig feces declined from 34.0 percent in 2015–2016 to 5.1 percent in 2017–2018; similar trends were found in human populations, indicating that the ban on colistin as a growth promoter (and reduction in its sale as tracked by the database) was having the intended effect (Wang et al. 2020).

In Brazil, a surveillance study in poultry was linked to surveillance of chicken products imported from Brazil into the UK; the findings indicated that while the prevalence of multidrug-resistant *Salmonella* was increasing over time, the strains were likely linked to animal vaccination practices and did not constitute a threat to human health (Alikhan et al. 2022).

Monitoring requires infrastructure for tracking and aggregating information, and relies on reporting effort (e.g., from seller, animal health professional, or farmer).[23] Considering use relative to animal biomass (via weight and the relevant animal population) is crucial to put monitoring information into context, allow for comparison, and identify where problems are. There are some challenges with biomass adjustments particularly for fish production, which may affect precision of per-animal or animal population use estimates (Narbonne et al. 2021). Similarly, illegal importation channels may affect quantity estimates. Poor standardization and harmonization, with variation in sample types, testing methods, and criteria, may affect interpretation of results (Schaekel et al. 2017). Stakeholder or value chain mapping to determine relevant distribution channels may be a useful input to shape monitoring scope. International initiatives, such as reporting to the World Organisation for Animal Health (WOAH), can encourage monitoring (WOAH 2022), as can industry standards and consumer demand. Surveillance of AMR in animals requires enhanced laboratory capacity, particularly national and subnational bacteriology services as well as PCR or sequencing platforms. Depending on the specific objectives, surveillance may involve a range of potential inputs, including sample types and settings (e.g., live animals on farms, clinical specimens from sick animals, or animal products in the food chain); selection should consider logistics and cost in addition to information needed to assess risk and target action as warranted. Links with the private sector can supplement data collection but require mandates or other mechanisms to incentivize participation in surveillance. Standard monitoring and surveillance methodologies allow for findings to be aggregated across different data providers, such as provincial offices; however, initial studies can provide the basis for developing a national or subnational system (Tate et al. 2022). Improving data completeness will also require digitization as well as data integration (clinical, laboratory, pharmacy) to pair resistance and consumption data for epidemiological analysis (MAAP 2022). Linking surveillance findings to action requires supportive mechanisms to be in place to interpret and make use of information in prescribing and other policies and practices. It is crucial to ensure both formal and informal (e.g., unregistered) farming systems are reached in monitoring and surveillance programs and served by associated interventions.

Knowledge gaps include understanding of the ideal supportive infrastructure (e.g., training, buy-in), mode, and frequency of reporting at subnational (retail store or farm) level. It is not known how reporting validity is affected by substandard or falsified medicines, or by consumers' limited ability to differentiate antimicrobials. Incentives for reporting of antimicrobial use and AMR are unclear at present, other than where required for prescribers and importers (and potentially sellers and farmers). For AMR surveillance, since baseline resistance levels in animal populations are not always well established, the epidemiological significance of detection and link to antimicrobial use practices cannot always be inferred with additional information.

23 The World Organisation for Animal Health (WOAH) collects information on use of antimicrobials in animals, acknowledging that additional work is needed to improve precision, including for on-farm data reporting of administration to animals. To date, most reporting is based on products sold, imported, or manufactured that are intended for use in animals. See WOAH (2022).

Overall, the ongoing monitoring of sales and use for animal antimicrobials and AMR surveillance in animals should be considered as a basis to inform other interventions. Government authorities should also be empowered to act on findings as appropriate, e.g., via change in regulations or via enforcement. Monitoring and surveillance programs may vary widely in their scale and scope (and current completeness, requiring capacity enhancement); for example, programs' focus may range from individual farms to aggregated points in the value chain. But programs should allow for comparability of findings to track trends over time.

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Agriculture and food sector

10 Promoting behavior change campaigns in animal production

Working with farmers, veterinarians, paraveterinarians, and other stakeholders to support behavior change away from the use of antimicrobials in animal production can help to increase the responsible and prudent use of antimicrobials. AMU for animal production is substantial and is projected to increase with rising demand for animal protein. Inappropriate use ranges from growth promotion, to incorrectly targeted or administered antimicrobials, to use of critically important antibiotics for human medicine (van Boeckel et al. 2017). As antimicrobial purchase and administration occurs directly by farmers in many settings, engaging farmers and others working in animal production and animal health and creating the necessary incentives (including possible enforcement strategies) will be important for changing demand and use practices. Studies on baseline behaviors and behavior change campaigns in farmers were reviewed for effects on knowledge and use.

While most baseline studies document poor understanding of AMR, there are some promising results that suggest effectiveness for behavior change. Case studies are reported from Cambodia, Kenya, the Netherlands, and Europe (a multicountry study). In Cambodia, a study of commercial farmers, feed retailers, and veterinarians found that overuse was linked to belief that antibiotics were necessary for animal raising, limited knowledge, unrestricted antibiotic access, and weak monitoring and control systems (Om and McLaws 2016). A study of poultry producers in Kenya found that antibiotics were used for a range of reasons, from egg production improvement to growth promotion to managing disease symptoms (Kiambi et al. 2021). Specific behavior change interventions in the animal production industry are limited. A review conducted in 2017 on farm and veterinarian AMU and prescribing found only seven intervention studies and 45 studies on facilitators and barriers (Gozdzielewska et al. 2020). In the Netherlands the RESET (Rules, Education, Social Pressure, Economics and Tools) Mindset Model was used as a basis for designing a behavior change intervention with required and voluntary components; it resulted in a 47 percent reduction in antibiotic use and a decline in use of critically important antibiotics to very low levels by the dairy sector between 2009 and 2015 (Lam et al. 2017). In a study of 70 pig farms in Belgium, France, Germany, and Sweden, herd farmers and herd veterinarians set targets for AMU and saw substantial reductions in use (Collineau et al. 2017). Withdrawal times have been set in a number of countries to require a period of nonuse prior to sale, with varying adherence outcomes reported.

In theory, behavior change campaigns can be feasibly implemented in a range of settings, and there appears to be a need to strengthen general awareness around appropriate AMU as a first step. Possible reasons for success or failure vary, and include religious beliefs and policies, participation in farm collective organizations, and lack of awareness about the importance of adherence or enforcement. AMU tracking is necessary to guide precise interventions. The intervention examples above involved intensive national, industry, or veterinarian-supported initiatives versus relying solely on individual farm-level decisions. This supporting architecture is likely to be a constraint in countries with weak veterinary services. Viable solutions vary widely between smallholder and large-scale commercial livestock producers, and affordability of antimicrobials is a factor influencing low investment in basic hygiene and biosecurity measures (Caudell et al. 2020). “Nudges” in product labeling and marketing have been suggested as possible interventions, e.g., availability of vaccines in smaller vial sizes for small-scale producers, and awareness campaigned accompanied by basic animal health training programs for farmers (Mupfunya, Qekwana, and Naidoo 2021).

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Knowledge gaps include the optimal format and length of interventions. Current practices and motivations, as well as production systems and stakeholders, require context-specific approaches to understand AMU, set realistic targets, and develop behavior change strategies. It is unclear how AMU for symptomatic illness will be reduced/targeted in the absence of widespread diagnostic services.

Behavior change interventions are advisable in settings with sufficient alternatives to support reduced AMU. Appropriate practices should be tailored to the specific agricultural production context, given differing ecological and climatic conditions, access to services, and disease risks.[24] Enabling factors, including support from national, industry, or veterinarian initiatives and incentives for farmers (including cost considerations and regulations), are likely to promote success of this intervention as opposed to relying on individual farmers' decisions alone.

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Agriculture and food sector

11 Increasing veterinary laboratory capacity and access to diagnostics

Rapid diagnosis and determination of sensitivity to antimicrobials can help veterinarians determine the most effective and appropriate treatment for sick animals and limit the use of antimicrobials where they are not needed or are unlikely to treat infection. As a part of this effort, strong laboratory capacity plays a key role in the animal health system, contributing to a number of functions and purposes.[25] As with human medicine, access to rapid diagnostics can be extremely limited, and prescribing often defaults to symptom-based clinical diagnosis. This understanding was reinforced by a study of animal health professionals in 20 African countries, which found that lack of diagnostic facilities and susceptibility tests is a major challenge (Tebug et al. 2021). Several major bacterial and viral livestock diseases have similar clinical signs that often require laboratory diagnosis for determination. Susceptibility and quality testing can also inform change in treatment protocols and/or enforcement and veterinary medicine supply chain strengthening. Studies on laboratory enhancement and access to diagnostics were reviewed for effects on prescribing.

The development of rapid tests is being pursued and shows promise for the future, and findings indicate the utility of laboratory services; but few field-ready technologies are available to inform immediate AMU and susceptibility testing. Evidence is largely focused around diagnosis of a specific disease, typically one commonly associated with a given production system. Case studies are reported from New Zealand, Chile, and the UK. Several studies do discuss the increasing availability of point-of-care options for diagnosis of clinical mastitis, a bacterial disease affecting dairy cows (e.g., Malcata et al. 2020). In New Zealand, where mastitis is the primary reason for antibiotic use in dairy cows, an intervention was tested that compared waiting for diagnosis and antibiotic susceptibility test results (which take at least 24 hours) versus immediate treatment. No difference was detected in cure rates nor in the days of milk withheld from supply, but the group undergoing testing saw a 24 percent reduction in antimicrobial use (Bates et al. 2020). Technologies such as multiplex real-time quantitative polymerase chain reaction (qPCR) assay can allow for broader screening and an alternative to bacterial culture tests, but require formal laboratory facilities. In addition to immediate diagnosis and treatment needs, laboratory capacity for surveillance has utility for long-term data monitoring to determine susceptibility profiles and to link use and resistance patterns, as conducted via secondary data analysis in the US (Yin et al. 2021). In Chile, a risk-based surveillance effort for diagnosis of *Piscirickettsia salmonis*, the main reason for antibiotic use in salmon farms, was identified as a cost-effective early detection strategy (Delphino et al. 2021). A study of perceptions of veterinarians working at UK livestock farms found that rapid diagnosis introduces complexities into antimicrobial stewardship, including changing the flow of information and responsibilities in food production chains, with possible implications for disease reporting and management (Buller et al. 2020).

25 In addition to contributing to surveillance and diagnostics as examined in this review, laboratory capacity plays an important role in monitoring the quality of medicines, including antimicrobials, though the types of laboratories and skills required vary by function.

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At present, rapid tests are not widely available for animal disease, but standard microbiology laboratory infrastructure can be leveraged and strengthened for ongoing population-level surveillance as well as outbreak investigation support. The intervention relies on access to laboratory services and animal owners' willingness to pay for diagnostics (or provision of testing via veterinary services). Because of the possible implications for the relationship between the veterinarian (or other animal health extension service worker) and the farmer in disease reporting, any design and rollout of this intervention should be informed by ongoing farmer and veterinarian consultation.

As with laboratory capacity for humans, there is poor baseline knowledge of co-infections and in some cases poor test sensitivity and specificity. There are also knowledge gaps on incentives to promote farmer uptake of rapid diagnostics and possible changes in disease reporting structures.

Improvements of veterinary laboratory capacity for AMR outcomes may require phasing in with more vertical (disease-based) strategies that can be deployed for rapid diagnosis. These should be pursued in tandem with broader animal health surveillance and monitoring for infections, antimicrobial use, and resistance.

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Water and environment sector

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12 Improving infrastructure to provide access to water and sanitation in health care centers

Improved water and sanitation contribute to the improvement of population health outcomes through reduced burden of disease. Health care settings are a significant source of infections, particularly among patients with weakened immune systems; this problem is exacerbated by inadequate infrastructure in some LMIC settings. Increasing water and sanitation infrastructure in health care facilities as part of overall WASH enhancements is a priority for preventing initial infections, their spread, and the development of resistance—both within facilities and in the broader community. Piped water systems (e.g., for safe drinking water) and waste treatment technologies (e.g., for sewage and health care waste management) are among the key infrastructure improvements that are a foundation for IPC. The evidence was reviewed on the impact of upgraded water and sanitation infrastructure in health care facilities on AMU, water quality, hand hygiene, and infection rates.

WASH infrastructure in health care settings is a foundation for IPC, though the evidence in relation to AMR-specific outcomes is mixed from both HIC and LMIC settings, and most studies to date report on cross-sectional findings or examine multiple interventions. A systematic review of waterborne contamination sources and transmission routes in neonates and their mothers in health care settings included papers (n = 25) from mostly high and middle-income settings; of these, the select studies that examined control measures indicated that faucet cleaning helped to control infections (Moffa et al. 2017). Case studies are presented from Bangladesh, Liberia, South Africa, Rwanda, and Ireland. In a study of health care facilities in Bangladesh, environmental contamination and poor hand hygiene practices were observed even in facilities with improved water sources, indicating that infrastructure may not automatically translate to improved hygiene behavior and may require a broader scope of interventions for success (Horng et al. 2016). In Liberia, renovations were conducted to provide basic WASH services in two hospitals originally without WASH services, resulting in an increase in hand hygiene compliance among health care workers from 36 percent to 89 percent in one hospital and from 86 percent to 88 percent in another (Kanagasabai et al. 2021). In South Africa, a study found that of 50 clinics examined in the country's rural Vhembe district, 80 percent used an improved water source, but microbial quality in 17–64 percent of water taps was below the safe drinking water standard set by the country and WHO (Potgieter et al. 2021). In Rwanda, women undergoing caesarean section at a rural hospital were less likely to develop surgical site infections in hospitals with consistent piped water in a postpartum ward, whereas interruptions in water supply for a day or more were linked to a 2.6 times higher likelihood of such infections (Robb et al. 2020). A separate study of 17 health care facilities with piped water in Rwanda found that not all had functional water access points; of 142 handwashing locations in the facilities, only 32 percent had water and soap, and none had on-site capacity for performing repairs (Huttinger et al. 2017). A study in a dental hospital in Dublin, Ireland, indicated the presence of *Pseudomonas aeruginosa* bacteria in washbasins, likely through the wastewater piping network, though any clinical burden from this exposure route was not determined (Moloney et al. 2020).

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Feasibility and enabling factors include access to infrastructure, such as adequate water source(s), facilities, and sanitation systems, and ongoing disinfection as needed. Some types of water taps have been found in studies to be more susceptible to microbial contamination, and piping conditions may facilitate the formation of biofilms (e.g., with stagnant water and low water pressure), reinforcing the importance of IPC expertise in design and ongoing monitoring and maintenance of WASH infrastructure (Halabi et al. 2001; Moloney et al. 2020). Access to functional water points also presents a challenge for hospitals in drought or conflict-affected settings, where other IPC measures may be more readily implementable in the short term (Lowe et al. 2021). A study of rural health care facilities with maternity wards in 14 LMICs found that availability of an improved water source was one of the four system-level factors associated with having the "six cleans" recommended by WHO (the other three factors were an IPC protocol, a budget for WASH, and IPC outreach with the community) (Cronk et al. 2021). WASH infrastructure is important, but likely insufficient, in IPC; proper handwashing and cleaning services must also follow, and management-related approaches may also be beneficial to enable a water safety plan (Dyck, Exner, and Kramer 2007; WHO Regional Office for Europe 2022). The placement of handwashing stations can also play a role in uptake, with inaccessibility reported as an impediment to good hand hygiene (Engdaw, Gebrehiwot, and Andualem 2019).

Knowledge gaps include the relative importance of WASH infrastructure compared to other infrastructure among different settings, depending on transmission routes and pathogens of concern. For example, ventilation and patient distancing can play a crucial role in reducing some airborne infections (Stiller et al. 2016). The relative benefits to improved hand hygiene and other IPC enabled by WASH infrastructure may require examination, particularly where water and sanitation quality varies. The epidemiological significance of improved hospital WASH infrastructure compared to improved community WASH infrastructure in reducing environmental dissemination and community transmission of resistant pathogens and genes is likely to be context dependent.

Sufficient WASH infrastructure underpins IPC and the prevention and control of health care–acquired infections, and further study will help elucidate how it affects AMR-relevant outcomes in practice alone and with community-based WASH interventions. This intervention is likely to be synergistic with hand hygiene and other IPC measures, as well as quality monitoring and system maintenance.

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Water and environment sector

13 Implementing effective treatment and disposal of sewage and wastewater

Advanced treatment technologies can help reduce the spread of antimicrobial residues and antibiotic-resistant bacteria and genes into the environment. Untreated effluent and dissemination of residues and resistant pathogens and genes are documented from a number of sources, including hospital effluent. The limited capture of resistant bacteria presents potential risks of dissemination via drinking water, irrigation, and aquatic environments, including through surface water contamination. Waste treatment is particularly important in potential AMR hot spots such as hospitals and intensive food-animal production systems, as demonstrated by detection of resistant strains in effluent (e.g., King et al. 2021). Where waste is effectively captured, wastewater treatment plants (WWTPs) may use multiple technologies for treatment of raw waste before release into the environment or reuse. Multiple stages are usually involved, from initial stages of removing solid materials to tertiary stages of removing nutrients and disinfecting liquid effluent. Conventional tertiary methods focus on chlorination, which is recognized as having limited impact on removal of resistant pathogens and genes. More advanced treatments such as ozonation, ultraviolet (UV) irradiation, and advanced oxidation processes (chemical reactions to treat wastewater) were reviewed for effects on antimicrobial residues, resistant bacteria, and genes.

Both conventional and advanced methods produce variable effects on microbial organisms. Case studies are presented from India, China, and Brazil. A study in Tamil Nadu, India, reported a decrease in the number of bacterial colonies along seven stages of hospital effluent treatment, ultimately finding removal of some but not all types of resistant pathogens, meaning these pathogens are present in wastewater entering the lagoon to be recycled (Kalaiselvi et al. 2016). Several studies have been conducted on constructed wetlands in China. One study compared the concentration and removal of seven antimicrobial resistant genes in wastewater and biosolids from three municipal WWTPs using different advanced treatment methods (Chen and Zhang 2013). Compared to the standard WWTP treatment, the constructed wetland was found to have similar efficacy in removing resistant genes (reductions of one to three orders of magnitude) while being more effective in reducing relevant abundance. Biological aerated filter had a more limited effect, and no effect was found from UV disinfection. In Brazil, constructed wetlands demonstrated successful elimination of ciprofloxacin by the time of outflow (Sakurai et al. 2021). Another promising technology involves the solar photo-Fenton and electro-Fenton methods; experimental studies indicate high rates (~80 percent) of inactivation of resistance-conferring plasmids (which carry resistant genes), including in real wastewater samples sourced from a treatment plant in Brazil with resistance-conferring plasmids added (Vilela et al. 2021; Chen et al. 2020).

Feasibility varies by setting and method. Wastewater chlorination has been found to increase some resistant bacteria and genes, and for sewage (biosolids), anaerobic digestion can result in a shift in microbial diversity, such as favoring survival of heat-tolerant microbes (Zhao and Liu 2019). Advanced treatments have been tested in laboratory-based studies, which indicate the effectiveness of advanced oxidation (e.g., thermal plasma, UV/H_2O_2) in partial or complete degradation—but results vary by complexity of the wastewater "matrix" (composition) as well as duration of treatment, temperature, pH, and number of methods used. These technologies entail high energy consumption, reagent use, and cost. PCR testing is often used to assess effectiveness of removal of antimicrobial-resistant bacteria and genes. Additionally, use of WWTPs assumes well-maintained sewage infrastructure and the absence of open defecation, both of which are substantial challenges in some LMIC settings.

Gaps in knowledge relate to field deployment of methods (which are largely experimental at present). The current gold standard can be considered sequential treatment using multiple technologies to promote comprehensive removal of contaminants; however, even in studies in developed countries, some results from on-site (versus laboratory-based) treatment show improved but not full removal of bacteria and genes (Paulus et al. 2019).

Waste and wastewater treatment is important for several outcomes, and financing of this intervention for AMR outcomes should consider water composition and viability of removal. Wastewater composition analysis will be important in the design of advanced wastewater treatment interventions, along with ongoing maintenance of infrastructure and monitoring. Since antimicrobial residues, resistant bacteria, and genes can have different implications for disease burden, the epidemiological significance of incomplete removal can be assessed on a localized basis to determine if additional waste or wastewater treatment steps are needed. When incomplete removal does present a threat, other interventions may also be needed (e.g., vaccination or reduction of water source contamination).

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Water and environment sector

14 Improving waste management practices in agricultural and aquaculture production/processing

Limiting the flows of wastewater, manure, and agricultural runoff containing antimicrobials, antimicrobial residues, and antimicrobial-resistant bacteria helps limit the spread of resistance. Waste products from agriculture and aquaculture production and processing are potential sources of antimicrobial residues, resistant bacteria, and antimicrobial resistant genes. A major concern relates to product formulations for livestock, which result in low absorption of antimicrobials in some species (with as much as 90 percent excreted unmetabolized), as well as poor targeting of antimicrobials in aquaculture. The recycling of manure and other agricultural waste products may facilitate environmental dissemination. Relevant practices and risks should be considered in the context of different production systems; in general, intensive monogastric production (commercial pig, cattle, poultry) is a major source of agricultural waste. Proper waste management and pretreatment of waste from agriculture and aquaculture are thus recognized as potentially important to avoid dissemination of active pharmaceuticals and resistant microbes and genes into the environment. Studies involving impact of anaerobic digestion, composting of manure, and manure lagoons on antimicrobial residues and genes were reviewed.

The few available studies point to reduction of residues and in some cases genes, though results are not uniform. While studies report effects of waste treatment for a number of contaminants, the evidence base specifically on antimicrobial residues and resistance is limited. Case studies from the US, China, Vietnam, and Japan are presented. In the US, manure from a dairy farm (n = 650 cows) was processed in a rotary drum composter, with significant decrease in oxytetracycline residues and the four antibiotic-resistant genes (ARGs) screened for (Oliver et al. 2020). In China, the mcr-1 colistin gene was detected in livestock waste in 2016 prior to the ban on use the following year; while genes were found to increase in dried versus fresh manure, anaerobic digestion was found to reduce gene abundance (Xia et al. 2019). In Vietnam, a study of pig farming operations found most farms (70 percent) used biogas systems to treat animal waste, while a portion (19 percent) used composting and the remainder discharged waste into water sources. Fluoroquinolones and sulfonamides were found respectively in 6.3 percent and 22.9 percent of wastewater samples (Pham-Duc et al. 2020). A study in Japan of recycled organic material from several sources found that swine manure was the only one to contain certain antimicrobials, reflecting different antibiotic absorption rates in different species. In the US, upstream sources at three swine farms were found to have similar concentrations and abundances of tetracycline-resistant genes, but varying levels (some decreasing and some increasing) in the manure lagoons. As with the mcr-1 study above, increases in resistant genes were likely due to their positive selection by specific environmental conditions (Barkovskii, Manoylov, and Bridges 2012).

Waste treatment relies on containment of waste as it is generated, which may not be practical in certain settings or production systems. Containment is especially a challenge for aquaculture production. Each technology has specialized requirements (e.g., moisture, temperature, and number of days for fermentation) (Motoyama et al. 2011), and high ARG abundance may reduce effectiveness of anaerobic digestion for gene degradation (Xia et al. 2019). Farmer education on optimal use of waste treatment technologies is important to support implementation success. In noncommercial farm settings, access to equipment and/or infrastructure for waste treatment is likely to require external assistance.

Regulatory requirements may incentivize farmers to participate in waste treatment, as will cost considerations (promoting low-cost but effective methods). The species of animal and AMU practices will drive relevance of this intervention for addressing emergence and spread of AMR.

There is poor understanding of how different technologies and practices across production systems may potentially increase or decrease presence and dissemination of residues and genes. There are knowledge gaps on the epidemiological significance of residues, and particularly genes, released via waste from agriculture and aquaculture for human and animal health, in relation to antimicrobials not considered important for use in human medicine. To better understand the environmental determinants of the reduction or proliferation of genes, it will likely be necessary to test and potentially refine protocols for each treatment method and its use in different production systems and environmental settings.

Treatment of waste/wastewater and runoff from animal production is prudent in all settings, but the overall picture of effects on AMR is uncertain, especially for aquaculture. Investments should be paired with farmer access to innovation, treatment technology, and education/incentives on use, as well as monitoring to inform refinements in waste management as necessary.

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Water and environment sector

15 Improving safe disposal of unused antimicrobials

Improving antimicrobial disposal practices can direct unused antimicrobials from household settings to pharmacies or other safe disposal points. Improper disposal can result in dissemination of pharmaceuticals into the environment via trash, sewage, and manufacturing or other waste, potentially contaminating water systems. Uptake of safe disposal programs for all medicines was reviewed for evidence of effectiveness. The evidence base largely evaluates self-reported program awareness and participation.

Several safe disposal programs have been trialed; however, outside of long-standing programs in Europe, many are relatively new. These newer programs vary in scope, have met with limited uptake, and have been established without broader systems in place. Case studies from Ghana, Malaysia, Kuwait, the Netherlands, and Turkey are presented. A systematic review of studies (n = 25) published between 2005 and 2015 reported that some countries used a pharmacy return program, with supervised incineration or recycling of medications (Paut Kusturica et al. 2016). The highest return of unused medicines was reported from the Netherlands, estimated at 58 percent (Alnahas et al. 2020). In Ghana, the Disposal of Unused Medicines Program (DUMP) is operational but reported as limited in geographic scope (present only in government-affiliated hospitals and clinics), with very low awareness of the program among participants (< 20 percent of participants). In Malaysia, the government offers a take-back program at hospitals and clinics. In Sabah, of patients (n = 244) at outpatient pharmacies, 54 percent had heard about the return program, and 26 percent reported they had used it (Yang et al. 2018); in Selangor, a survey of households (n = 103) found only 25 percent had utilized the program (Ariffin and Zakili 2017). Several studies have tested collection via provision of special envelopes, with low reported return. In Kuwait, household participation in medication return was more successful in a small sample of households (n = 14) that received in-person interviews and assistance, versus no uptake by households receiving only educational material and envelopes for pick-up (n = 200 households) (Abahussain and Ball et al. 2007). In Serbia, a study of patients (n = 800) visiting pharmacies in four cities found ~80 percent were likely or very likely to participate in a take-back program, but less than half would be willing to pay for collection (Paut Kusturica et al. 2020). In a workplace-based education and take-back campaign in Turkey (n = 1,112 participants), 28.6 percent of participants reported they had brought back medicine(s); there were also reports of increased proper at-home storage practices (Akici, Aydin, and Kiroglu 2018).

The intervention appears feasible if centralized collection and destruction infrastructure is in place, but requires awareness, access, and clear designation of responsibility and financing for success. Public trust in programs is necessary; concern over resale of medicines has been suggested as a possible reason for low uptake. Program responsibility varies from the pharmaceutical industry to national agencies (e.g., health, drug enforcement), local governments, and communities (Barnett-Itzhaki et al. 2016; Lin et al. 2020). Studies indicate poor awareness of waste management by medical and dental professionals and students (e.g., Ranjan et al. 2016). Safe disposal relies on infrastructure to collect and properly dispose of antimicrobials, and on training and awareness to support participation. Supply-side interventions related to doses disbursed and treatment compliance, along with incentives (e.g., a voucher mechanism), could help to address the quantity and disposal of unused antimicrobials. Tracking sales data would provide a baseline.

There are gaps in knowledge about safe disposal-seeking behaviors by patients with real or perceived future need for antimicrobials. Gaps are greater in settings with high rates of bacterial illness and/or low access to prescriptions.

Safe disposal of antimicrobials remains important, but the evidence for the success of centralized medication take-back programs overall appears limited. Safe disposal may warrant consideration as a second-line priority once other interventions are in place, or may be paired with other investments such as public awareness to reduce demand, monitoring of antimicrobial use, and access to diagnostics. To ensure country-wide reach in LMICs, there is a need to develop programs that are connected to overall disposal systems and that are reinforced by uptake campaigns.

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Water and environment sector

16 Monitoring presence of antimicrobial residues and antibiotic-resistant bacteria and genes in water and sanitation systems

Monitoring of water and sanitation systems can generate data on the type of antimicrobials being used, as well as resistance patterns, helping to guide authorities on the appropriate actions to take. This information is important in the absence of reporting systems for AMU in humans and animals and can help determine potential for dissemination via shared or recycled water sources and the environment. Monitoring may detect concentration of residues (indicating presence of specific antimicrobial compounds, implying use) as well as antibiotic-resistant bacteria and antibiotic-resistant genes (Baquero, Martínez, and Cantón 2008). This review focused on effects of monitoring of antimicrobials (via residues) and antimicrobial resistance in water and sanitation systems on detection and disease investigation.

There is good evidence that sampling at different points in the water and sanitation system, such as along WWTP processes, is effective in detecting antibiotics in the water supply and informing where treatment enhancement is needed. Monitoring studies were conducted mainly for water and to a lesser extent for waste. Monitoring studies were reported from a variety of HIC and LMIC settings; it should be noted that the state of knowledge was limited around ARG presence (e.g., Adesoji et al. 2015). Case studies are presented from Europe, Canada, Brazil, China, and Pakistan. A study conducted at WWTPs in seven European countries reported that residues of 17 antibiotics out of the 53 screened for were found in final effluent (Rodriguez-Mozaz et al. 2020). The findings allowed for selection of a subset of residue monitoring targets for antibiotic pollution. Retrospective analysis examined reports of residues from aquatic samples in 47 countries against concentration levels that are unlikely to result in development of resistance ("predicted no effect environmental concentration") and found that 7.9 percent of antibiotic analyses exceed the level, with hospital and industrial wastewater demonstrating antibiotic profiles of concern (Booth, Aga, and Wester 2020). In a study in three First Nation communities in Canada, bacterial contamination was found to occur post-treatment in storage and distribution infrastructure, with ARGs also detected (Mi et al. 2019). In Brazil, a monitoring study compared ARGs from urban and hospital wastewater, finding genes encoding for multidrug resistance in 33.3 percent of isolates (Zagui et al. 2020). Several studies also point to monitoring as a key component in outbreak investigation, such as sampling of drinking water from cases and control households in a ceftriaxone-resistant *Salmonella* Typhi outbreak in Pakistan (water samples ultimately revealed high contamination with *E. coli*, leading to an improvement of water chlorination and implementation of fecal sludge treatment processes) (Yousafzai et al. 2019). In some cases, monitoring has been conducted as part of wider water safety testing. A study in nonurban sewage treatment plants in China reported a significant association between the presence of ARGs and some heavy metals (Xu et al. 2017).

In general, water and sanitation monitoring are feasible with standard technologies countries already have in place. Common methods include bacterial cultures and basic coliform testing, chromatography (chemical detection), and PCR- and qPCR-based methods (microbial and gene detection). Drug-resistant fecal coliform testing in WWTP effluent was conducted in 22 countries across five continents (Marano et al. 2020). Other methods typically require laboratory-based infrastructure. Water quality may affect detection (Pazda et al. 2019). Monitoring requires ongoing collection, reporting, and analysis to inform risk assessment and management. There may be a major gap in translating findings from monitoring into action if WASH infrastructure is lacking or poorly maintained.

The adequate scope for sampling and testing is a knowledge gap. Improved monitoring and comparison to background environmental data will support more precise monitoring needs (samples and sites and antibiotics, bacteria, and genes to screen for) and interpretation of findings. Understanding is also limited around the precise level of threat from residues and genes transmitted through waste and wastewater, including how community or individual-level behaviors may increase or decrease risk.

Water monitoring appears to generate useful information in all settings. However, this intervention in particular requires a One Health approach to put findings from water monitoring into context about risk to humans and animals. It is likely to be synergistic with water treatment (and aquatic ecosystem protection), as well as regulatory interventions to address sources of contamination. It reinforces the importance of laboratory capacity and ongoing laboratory operations.

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Multisector

17 Detecting and deterring substandard and falsified antimicrobials

Tackling substandard and falsified (SF) antimicrobials requires interventions to improve detection and deterrence supported by regulatory action, including monitoring-based enforcement. Antimicrobials are among the most commonly reported SF medicines (WHO 2018). Although poorly quantified in relation to veterinary use, SF antimicrobials are a concern for both human and animal medicine. Detection and deterrence operations may involve traceability systems, quality screening, criminal justice and law enforcement, and regulatory standard setting. Potential results relevant for this intervention include reduction in rates of substandard and/or falsified products and improved treatment effectiveness. Studies involving detection interventions were reviewed for effects on SF product tracking, product quality, and enforcement.

Overall, the evidence base is mixed for effectiveness in low-income countries, though some promising findings indicate the scale of the problem can be successfully reduced. The World Customs Organization (in partnership with WHO and others) has conducted recent capacity strengthening operations with customs officials to counter the flow of SF medicines.[26] Case studies are reported from Cambodia, Ghana, Kenya, Lao People's Democratic Republic, and Nigeria. In Cambodia, a study using open surveyors and mystery clients to collect artemisinin-containing antimalarials (n = 291 samples) from drug outlets found no falsified medicines; all the medicines contained active pharmaceutical ingredients (although only 69 percent were reported to be of good quality). These findings indicated effectiveness of regulation, enforcement, education, and communication campaigns aimed at tackling poor-quality medicines in the country and addressing concern over antimalarial resistance (Yeung et al. 2015). Several detection options have been trialed. Nigeria's Mobile Authentication Service, initiated in 2010, uses a serialized code for immediate verification by consumers via text message ("OK" or "fake—don't use"); the cost of the label is incurred by suppliers. Nigeria has reported a reduction in counterfeit and substandard products (estimated at > 60 percent in 2001 compared to only 5 percent in 2012), though it is unclear what effect mobile authentication had on this decrease (Spink, Moyer, and Rip 2016). Reliability of testing methods appears to vary. A blinded study for a specific antimalarial medication in Lao PDR found the US Food and Drug Administration's CD3 device to be highly accurate (Tabernero et al. 2015). A comparison of three devices piloted in Ghana (the US Food and Drug Administration's CD3+, the GPHF [Global Pharma Health Fund] Minilab, and the Thermo Scientific TruScan hand-held Raman spectrometer) found that detection/devices/methods for antimalarials varied in sensitivity and specificity (Batson et al. 2016). Paper analytical devices (PADs) for falsified antibiotics and antibiotic paper analytical devices (aPADs) for substandard antibiotics offer a simplified screening option. Based on the relatively low cost of PADs and aPADs (US$3) compared to standard high-performance liquid chromatography, a modeling study suggested a potential return of nearly US$15 million from potentially increased removal of SF amoxicillin to support effective treatment of childhood pneumonia (Chen et al. 2021). INTERPOL's multicountry operations on substandard and falsified medicines and medical products have led to seizures, identification of suspects, and in some cases arrests.

26 For information about regional and global efforts to fight SF medical products, see the World Customs Organization website, https://www.wcoomd.org.

Feasibility largely rests on screening capabilities. A major challenge is the scale of SF medicines, which may require targeting of efforts to specific antimicrobials. Sourcing via manufacture in country versus via import may demand different approaches to interception as well as regional coordination. Limitations can include the need for multiple screening methods to examine both dosage and packaging validity, need for mobile signal and power reliability, and lack of connection to the product's chain of custody. Field-based or local screening (e.g., via Minilab technologies) may help narrow down the quantity of samples for costly pharmacopeial confirmatory screening (Petersen et al. 2017). Constraints can negatively affect community pharmacist perceptions (see for example Oyetunde et al. 2019). Links between marketing and use in human health and animal health sectors should be considered, given the importance of regulatory capacity in human health and veterinary medicine (National Academies of Science, Engineering, and Medicine 2020).

Knowledge gaps include suitable incentives to participate in SF screening, and reporting and removal from the market, at various points in the supply chain. Quality thresholds may be challenging to act on without sufficient alternatives, particularly where access is limited.

This intervention is relevant for both human and animal medical products, and should be considered in tandem with suitable enforcement, deterrence, and incentives. The intervention could be AMR-sensitive or AMR-specific. Regulated supply in both human and animal medicine (and crop production) may also be a potential strategy for addressing SF medicines.

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Multisector

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18 Improving nutrition in humans and animals

Nutrition is well recognized as playing a role in the incidence and burden of disease. Nutrition status can affect susceptibility to infection and the severity and duration of disease in humans and animals, while some infections affect the body's ability to take up nutrients from food. Good nutrition is an important component in the management of HIV, for example, because it helps to maintain a strong immune system and supports absorption of medicines. In some food-producing animals, antimicrobials have been inappropriately used for growth promotion, and in humans antibiotics are routinely prescribed in the treatment of severe malnutrition and/or diarrheal disease, especially for children under five, contributing to a significant portion of AMU in some settings. Thus, improving nutrition is potentially important for action on AMR (Unger, Mark, and Pagliari 219; Moran 2019). Studies involving nutrition or food security improvements in humans and animals were reviewed for the effect of these improvements on AMU or AMR.

There are few studies reporting on population-level nutrition interventions related to AMU and AMR specifically, across all settings. However, there is some evidence supporting an association between indicators related to improved nutrition in the form of nutrient supplementation or probiotics and AMR outcomes. Case studies are reviewed from the US, Germany, Bangladesh and Sweden, and Egypt. In the US, a year-long randomized controlled trial of vitamin supplementation in elderly residents (n = 617) at nursing homes found normal levels of zinc were linked to lower pneumonia incidence and lower total antibiotic use compared to low zinc levels (Meydani et al. 2007). In Germany, a study of patients (n = 661) receiving parenteral (intravenous) nutrition in 82 hospital sites found that receiving higher levels (versus a lower dosage) of omega-3 fatty acids was linked to a 26 percent lower antimicrobial demand (Heller et al. 2006). Cross-sectional studies have looked at factors linked to AMR that are potentially indicative of nutrition status, such as correlations between weight status and AMU prevalence in the US National Health and Nutrition Examination Survey (Petersen et al. 2021). A systematic review of studies (n = 20) on probiotic-supplemented infant formulas reported reduced antimicrobial prescriptions, though evidence was mixed and varied by probiotic strain (Skórka et al. 2017). A comparison of infant cohorts examined the association between *Bifidobacterium* levels with AMR in early life in Bangladesh (a cohort with relatively high levels) and Sweden (with lower levels), finding higher levels reduced ARGs; however, the effect was not sustained at age two, raising questions about relevance over the life course (Taft et al. 2018). In food production animals, nutrition interventions have involved dietary intake changes and supplementation (e.g., protein, fiber, acids, and other additives), varying by species (Smits et al. 2021). In Egypt, a controlled study on *Bifidobacteria* and *Lactobacillus* probiotics as alternatives to antimicrobials supported weight gain and reduced mortality in broiler chickens infected with *Salmonella enterica* (El-Sharkawy et al. 2020).

Feasibility is likely to be limited by food insecurity, which affects access to and sustainment of nutrition resources. Detecting nutrition effects on clinically relevant AMR outcomes could require long-term monitoring. There are several possible indicators of nutrition for both humans and animal species (e.g., height, weight, dietary diversity, micronutrient intake); each target could involve different interventions. Food safety and water quantity and quality also play a role (Smits et al. 2021).

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There are key gaps in knowledge around community-based versus clinical nutrition interventions, as well as intervention scope. For example, improved nutrition efforts could range from counseling to direct provision of food supply. Additive effects with other interventions may be possible; a study on rates of infant diarrheal disease found nutrition incentives encouraged pickup of medicines at a collection location, a behavior that could affect nutrition and immune status as well as treatment compliance (Xue et al. 2010). Nutrition interventions could potentially help to reduce exposure to pathogens as well as antibiotic residues in the food supply, including through synergies with food safety initiatives.

Overall, improvements in nutrition have important benefits, including for the prevention and management of infectious disease, but precise roles in AMR outcomes are unclear at present. Benefits of improved nutrition may be evident in animal production, particularly in replacement of existing AMU for some veterinary medical uses as well as nonveterinary medical uses (e.g., growth promotion).[27]

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Multisector

19 Expanding vaccination coverage in humans and animals

Immunization is an indispensable tool in the protection against vaccine-preventable diseases in humans and animals. Expanding vaccination coverage is a priority goal to tackle vaccine-preventable illnesses in humans and animals, including those frequently treated by antimicrobials and more specifically those that lead to childhood deaths, such as pneumococcal disease, rotavirus, and Hib infection.[28] In addition to individual protection, vaccine strategies can provide indirect benefits; for example, animal vaccination can support herd protection, and some childhood vaccines have been linked to disease prevention in adults. Vaccination can also provide protective benefits where there is concern over development of AMR in pathogens with widespread distribution, as seen with increasing detection of extensively drug-resistant typhoid infections (Saha, Tabassum, and Saha 2021). The availability of vaccines varies for infections associated with high consumption of antimicrobials and potential for the development of resistance (WHO 2022). Studies were reviewed for effects of vaccination on AMU and AMR in humans and animal populations.

Overall, there is evidence that vaccination (in addition to reducing vaccine-preventable infections) affects AMR outcomes, particularly AMU, in all settings, though effects are mixed and study quality and robustness vary. Studies have mainly examined the impact of disease-specific vaccination (e.g., influenza, pneumonia, or typhoid) on AMR-related outcomes, versus a multiple-vaccine strategy. A Cochrane Collaborative systematic review (n = 96 randomized or observational studies) found evidence certainty varied by outcome, with high-certainty evidence that influenza vaccination reduces duration of antibiotic use in healthy adults (Buckley et al. 2019). Case studies are reviewed from the US, Lao PDR, Israel, the Democratic Republic of Congo, and Belgium. In the US, an analysis of influenza vaccination and antibiotic prescribing between 2010 and 2017 found that for every 10 percentage point increase in vaccination, there was a 6.5 percent decrease in antibiotic use, with effects most pronounced in pediatric and elderly populations (Klein et al. 2020). In terms of potential impact on the number of infections treated by antibiotics, a study of pneumococcal and rotavirus vaccines found that over 37 million episodes of antibiotic-treated illness annually are prevented in children under five years in LMICs under current coverage, and that expanded coverage for all children ages 24–59 months in LMICs would result in additional prevention of nearly 22 million episodes (Lewnard et al. 2020). In Lao PDR, pneumococcal vaccination was found to be significantly associated with a reduction inantibiotic use in the preceding fortnight in children 12–23 months, from 46.1 percent down to 34.4 percent in pre-and-post cross-sectional surveys (Satzke et al. 2019). Studies have reported pneumococcal vaccination campaigns leading to both the elimination of resistant strains from circulation in Israel and the persistence or increase in resistant non-vaccine strains in the Democratic Republic of Congo (Ben-Shimol et al. 2018; Birindwa et al. 2018). Vaccination is a widely used animal health tool, though studies related to AMR outcomes in animals are often reported in combination with other interventions. A review reported that various bacterial and viral vaccines in animals have been linked to significant reductions in AMU (Hoelzer et al. 2018). In Belgium, herd action plans involving vaccination plus biosecurity intervention on pig farms (n = 61) found significant reduction—between 32 percent and 52 percent—in AMU for treatment incidences based on production system, including reduction in use of critically important antimicrobials (Postma et al. 2017).

28 Although infection with rotavirus is caused by a viral pathogen (and thus not treatable by antibiotics), antibiotics are commonly prescribed for the disease in some settings—driving unnecessary use of antimicrobials.

Implementation feasibility is likely to vary based on epidemiological, infrastructure (e.g., cold chain), economic, behavioral, and other factors. While vaccination reduces the burden of primary and secondary infections (including resistant infections), a key challenge for human and animal health is that vaccination is pathogen-specific—and thus may lead to continued antimicrobial prescribing in the absence of precise diagnosis. Vaccine licensing varies by country, and protection depends on effectiveness against circulating strains, so that ongoing monitoring for the appropriate selection of vaccines is required. Expanded vaccination is estimated to avert substantial AMR costs (e.g., Lu et al. 2021) but requires sustained investment. Gavi financing supports vaccine introduction, procurement, and use in low-income countries, but middle-income countries can lack resources to introduce vaccines that are needed after graduating from Gavi. While playing a crucial and potentially leading role, vaccination alone is unlikely to be successful in the eradication of diseases, as noted for typhoid (where challenges include asymptomatic transmission, environmental exposures, and achieving universal vaccination) (Stanaway et al. 2020), and given vaccine hesitance and access constraints more broadly. In animals, current feasibility varies by production type; for example, classical injection practices are impractical in aquaculture, and there is presently limited availability of commercial vaccines for some fish species (WOAH 2015). Some veterinary vaccines present safety issues (Hoelzer et al. 2018). Additional human and animal vaccines, including for resistant pathogens, are in various stages of development, but require a number of elements to facilitate their development and use (immunological factors, product development, access, and implementation). Generation of evidence for the value of vaccines in preventing AMR may be constrained by the many parameters that can affect AMR expansion; however, most economic analyses of vaccines do not consider effects on AMR, likely underestimating their potential value (Micoli et al. 2021).

Key knowledge gaps relate to epidemiological significance of reduced antimicrobial prescribing for specific diseases, as well as incentives for vaccine uptake and sustainment by the public sector and individuals (e.g., patients or farmers). Additionally, while benefits of childhood immunization are broadly recognized, there are knowledge gaps around the utility of adult immunization in LMICs, including in relation to waning immunity and vaccine-preventable diseases linked to AMR in older adults (Sauer et al. 2021). In settings with limited access to diagnostics, it is unclear what effect vaccination may have on AMU for nonspecific symptoms (fever, respiratory, or diarrheal illnesses).

Expanding vaccination is a promising intervention for vaccine-preventable diseases linked to high AMU or AMR. It likely requires working in tandem with prescribing policy and awareness or behavior change campaigns, plus pathogen detection infrastructure and animal biosecurity.

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Multisector

20 Using closed water systems in aquaculture

Reducing the flow of waste to and from aquaculture farms is a potential way to limit the spread of pathogens and resistance. Effluent from aquaculture farms can be a source of environmental contamination by dispersing antibiotic residues and resistant pathogens and genes through surface water. Aquaculture production systems can produce significant changes in the structure of aquatic microbial populations (Zeng, Tian, and Wang 2017). Inputs from off-farm sources can also threaten fish health and production; for example, they may potentially introduce pathogens and other contaminants. Closed (or recirculating) systems limit the introduction and exit of water and waste to preserve water resources and reduce external contamination, typically filtering or treating contained water before reuse. Studies involving effects of closed aquaculture systems on AMR-related water treatment and water quality outcomes were reviewed.

The evidence base is limited on the role of closed system interventions in AMR outcomes. Some interventions have been trialed in LMIC and HIC settings, though primarily in experimental studies and with widely varying approaches. Case studies are reviewed from the Czech Republic, Korea, and Thailand. In the Czech Republic, a treated wastewater pond–aquaculture pond system was compared to a control pond fed by river water to simulate water reuse in aquaculture. The study monitored 70 pharmaceutically active compounds, including antibiotics and antifungals, in both systems and concluded that treated water influent in the aquaculture pond reduced ecotoxicological and antibiotic resistance water quality hazards (Fedorova et al. 2022). A study in Korea indicated that filter pore size affected how efficiently ARGs were removed from effluent (Kim et al. 2018). In Thailand, water from enclosed shrimp culturing ponds, which represents an amplifying environment for resistant pathogens and genes, was treated with ferrate. Water quality (organic waste accumulation), antibiotic structure type, and pH acidity affected antibiotic removal effectiveness (Suyamud et al. 2021).

There are likely feasibility challenges with current technologies and practices in many settings. Integrated farming practices common in some regions involve the reuse of waste products from poultry production as part of fish and vegetable production (Pruden et al. 2013). While closed systems are used at different scales (aquaria, commercial fish production), these are generally based on specialized and resource-intensive infrastructure (energy and cost). In settings where inland freshwater aquaculture is widespread, closed systems may be impractical. Although most systems are focused on land-based aquaculture, approaches vary. In marine pens, a major concern is invasion by wild fish that could lead to the introduction of pathogens and the type of genetic exchange that allows development of ARGs. Closed systems could potentially be integrated into biosecurity enhancements targeted to AMR outcomes.

Knowledge gaps relate to types of systems, as well as the significance of partial removal of antimicrobial residues, pathogens, or ARGs. Since most wastewater treatment methods do not comprehensively remove ARGs, it is unclear what effect water recirculation has on ARG maintenance or degradation, and ultimately on fish populations. Incentives for farm investments in closed systems related to AMR are unclear, but could evolve with shifting demand (e.g., for low-AMU products). Potential additive effects of closed systems for reducing AMU in aquaculture—or of other measures to improve water quality, such as modifications in feeding practices and fish density—are not yet known.

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There is a limited evidence base for this intervention's effects on AMR at present. At a farm level, there may be practical entry points as part of biosecurity enhancements in commercial operations. The technological methods used may vary widely by setting (from informal integrated systems to high-tech infrastructure); thus, utility should be considered in the specific context. Pairing this intervention with monitoring, specific guidance for use of antimicrobials in such systems, and farm-directed behavior change campaigns could help to shape its adoption.

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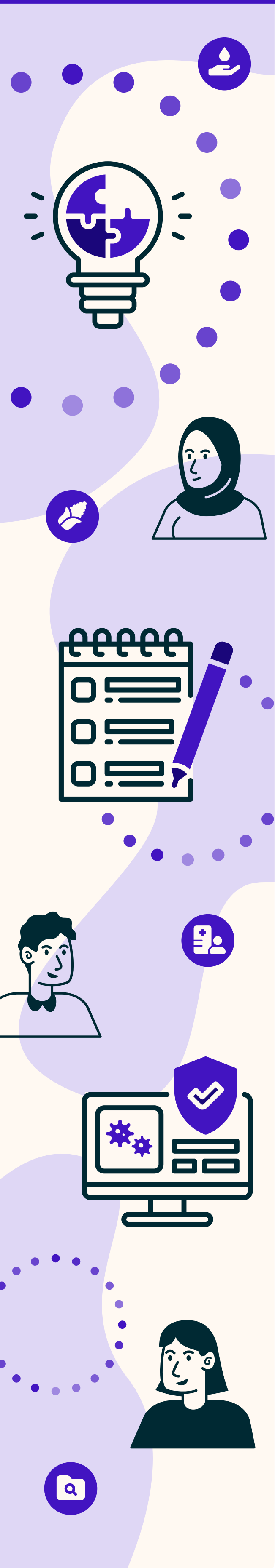
Chapter 4
Investing in AMR through World Bank Operations

A menu of options translating the list of intervention areas into World Bank operations can provide teams with scope to flexibly respond to the policy and lending dialogue in different contexts and in recognition that the intervention areas are a starting point, rather than a comprehensive list.



Chapter 4
Investing in AMR through World Bank Operations

Chapter 4 summary

This chapter describes how the 20 intervention areas identified in Chapter 3 can be translated into World Bank operations within and across the Health, Nutrition and Population (HNP), Agriculture and Food (AGF), and Water Global Practices (GPs). At the core of the World Bank's support to addressing antimicrobial resistance (AMR) is the provision of concessional International Development Association (IDA) and International Bank of Reconstruction and Development (IBRD) lending to finance interventions. This chapter is intended to provide task teams and clients with a starting point for incorporating interventions to address AMR in World Bank operations, specifically Investment Project Financing (IPF), Development Policy Operations (DPOs), and Programs for Results (PforRs). It provides options for discussion, which can be developed by task and client teams so that approaches are aligned with specific situations and needs.

This chapter begins by providing an overview of a 2022 portfolio review of World Bank lending; it then provides a menu of options for lending operations across the three sectors. At the time, the lending portfolio included 57 projects across 35 countries aiming at strengthening and developing agriculture, health, and water and sanitation systems that would prevent the emergence of diseases, reduce the need for antimicrobials, and limit the emergence and spread of resistance. The portfolio has since grown to more than 70 projects, and these have been drawn upon to inform the menu of options provided in this chapter. In addition, Appendix 3 provides detailed guidance on addressing the Environmental and Social Safeguards (ESS) considerations.

Introduction

This chapter provides guidance for task teams on how each of the following intervention areas can be translated into operations across the World Bank's three primary lending instruments: IPFs, Development Policy Financing, and PforRs. At the core of the World Bank's support to addressing AMR is the provision of concessional IDA and IBRD lending to finance interventions. With this in mind, Table 4 in Chapter 3 documented the intervention areas that have been identified across the HNP, AGF, and Water GPs, drawing on guidance from the United States Centers for Disease Control (CDC), the World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO), and World Organisation for Animal Health (WOAH).

Options for translating the list of interventions in Table 4 will be provided across sectors; however, the options will be broader than the areas covered in Chapter 3. This approach is meant to provide teams with scope to flexibly respond to the policy and lending dialogue in different contexts and in recognition that the intervention areas are a starting point, rather than a comprehensive list. This approach is also intended to respond to feedback from external partners on the range of areas that can be supported. For example, hand hygiene has proven to be an important and valuable infection prevention and control (IPC) measure through the COVID-19 pandemic. It is also an intervention that is amenable to continuation and scale-up in a range of different operations and to following on from COVID-19 operations focused on broader health and water sector reform. However, it is recognized that it is often part of a package of IPC and AMR stewardship interventions.

Within HNP, and of relevance to all sectors, the intervention areas have been translated into specific investments at the local, regional, and national level and vary in complexity. For example, improving antibiotic prescribing guidelines for health care workers can include national-level interventions such as changes to curriculums for health workers, regional-level interventions such as trainings for health workers, and local-level interventions such as monitoring and auditing of local practices. In addition, the options provided also seek to recognize that clients will be in different stages of readiness to address AMR. For some the focus will need to be on establishing initial infrastructure—for example, improving sanitation in health facilities. For others the appropriate intervention may be in developing advanced laboratory capabilities.

Overview of the 2022 portfolio review

In January 2022 a rapid review of the World Bank's IDA and IBRD lending was conducted to identify AMR investments, which were estimated to be approximately US$2 billion.[29] At the time, the lending portfolio included 57 operations across 35 countries aiming at strengthening and developing agriculture, health, and water and sanitation systems that would prevent the emergence of diseases, reduce the need for antimicrobials, and limit the emergence and spread of resistance. Thirty-four of the operations were by the HNP GP (60 percent), 8 were led by the AGF GP (14 percent), and 15 were led by the Water GP (26 percent). The portfolio had a wide geographical spread, with 32 operations in the Africa region, eight in East Asia and Pacific, six in South Asia, five in Europe and Central Asia, five in the Middle East and North Africa, and one in Latin America and the Caribbean. The portfolio has since grown to more than 70 operations.

Seventy-five percent of the portfolio was focused on human health investments. The review classified investments into three categories depending on whether they focused on human health, animal health, or both. Of the 57 operations, 43 operations (75 percent) include investments in human

29 In 2022 the World Bank's AMR portfolio was estimated to be between US$0.62 billion and US$2.32 billion; US$0.6 billion in financing was clearly allocated for AMR investments and an additional US$1.7 billion was tagged as addressing AMR, but without a specific budget breakdown.

health, six operations (11 percent) include investments in animal health, and eight operations (14 percent) include both. Out of 43 operations that focus on human health, six include investments to combat drug resistance related to tuberculosis (TB).

Sixty-eight percent of the portfolio addresses AMR-sensitive interventions. The World Bank classifies investments into two types of interventions: (i) AMR-specific interventions, which have as their main purpose the reduction of AMR emergence and spread—for example, promulgating and enforcing regulations to ensure people can obtain antimicrobial medicines only with a valid prescription; and (ii) AMR-sensitive interventions, which have other primary purposes, such as improved animal husbandry or a reduction in disease incidence, but which contribute indirectly to addressing emergence and spread of AMR. Of the 57 operations in the portfolio, 15 (26 percent) address AMR-specific interventions (13 in HNP; two in AGF), while 39 (68 percent) address AMR-sensitive interventions (20 in HNP, 15 in Water, and four in AGF). Five percent of the operations address both types of interventions (one in HNP; two in AGF).

The most common AMR interventions identified in the review were these: improvement of surveillance systems; strengthening of laboratory capacity; institutional and capacity building; water, sanitation, and hygiene (WASH) improvements in health care facilities; and prevention, detection, and treatment of TB. Operations focusing on TB have addressed AMR by including a component on the detection, treatment, and monitoring of drug-resistant TB. Operations focusing on animal health have usually addressed AMR indirectly through components addressing animal health and farm management, diagnostic and surveillance capacity, and livelihood support. Operations focusing on WASH in health care facilities indirectly address AMR through components on institutional WASH, health system strengthening, and improvement of health infrastructure.

Operations have drawn on a wide range of indicators to assess and incentivize investments in AMR, and 33 operations include AMR-related indicators in their results framework. The majority of indicators focus on the incorporation of One Health platforms and approaches, AMR scorecards, reduction in the total use of antibacterial drugs, the number of TB drug susceptibility tests, improved farm management practices, and access to improved water and sanitation in health care facilities.

Operations in the HNP GP have indicators on the successful establishment of One Health platforms, AMR scorecards, decrease in TB prevalence, increase in access to WASH in health care facilities, and health care waste management. Three operations focusing on One Health offer examples of investments aimed at improving animal and human health through the establishment of a regional One Health platform in West Africa (the Regional Disease Surveillance Systems Enhancement [REDISSE] Phases 1–3 [P154807, P159040, and P161163]. Another regional project in East Africa focuses on assessing and strengthening AMR testing in laboratories by deploying AMR scorecards (Africa CDC Regional Investment Financing Project in East Africa [P167916]). Five operations focus on decreasing drug resistance related to TB (AFR RI-East Africa Public Health Laboratory Networking Project [P111556], Emergency Tuberculosis Project in Papua New Guinea [P160947], Program Towards Elimination of Tuberculosis in India [P167523], Southern Africa Tuberculosis and Health Systems Support Project [P155658], and Burundi Public Health Laboratory Networking Project [P129551]). With regard to the TB operations' intermediate results (IR) indicators, the regional project in East Africa and the operations in Papua New Guinea and India focus on drug susceptibility and culture conversion rates among TB patients; the operations in East Africa, Burundi, and Papua New Guinea focus on drug-sensitivity testing for multidrug-resistant TB; and lastly, the regional project in southern Africa focuses on harmonizing standard operating procedures for surveillance of multi-drug resistant TB (MDR-TB). Another project in Serbia offers an example of an IR indicator that directly focuses on reducing the total consumption of antibacterial drugs for systemic use (Additional Financing for Second Serbia Health Project [P166025]).

Operations in the AGF GP focus on improving animal health by decreasing the prevalence of diseases and improving breeding and management practices. Two operations in Mali and the Sahel offer an example of investments aimed at improving animal health through vaccination programs: Regional Sahel Pastoralism Support Project (P147674) and Mali Livestock Sector Development Support Project (PADEL-M) (P160641). Other operations focus on improving breeding and management practices—for example, the Kyrgyz Republic Integrated Dairy Productivity Improvement Project (P155412). With regard to IR indicators, in Mali, the indicators focus on reducing disease prevalence; in the Sahel, the focus is on vaccination rates. In the Kyrgyz Republic, the focus is on the number of dairy producers who have improved farm management practices.

Operations from the Water GP focus on ensuring access to WASH in health care facilities, operations and maintenance of WASH facilities, and waste management. Four operations include indicators related to WASH facilities in health care facilities as Project Development Objective (PDO) indicators: Côte d'Ivoire Urban Water Supply Project Additional Financing (P170502); Results-Based Scaling Up Rural Sanitation and Water Supply Program in Vietnam (P152693); Rural Water Supply and Sanitation Project Tajikistan (P162637); and One WASH – Consolidated Water Supply, Sanitation and Hygiene Account Project Ethiopia (ONE WASH Phase II) (P167794). With regard to IR indicators, two operations include operations and maintenance of facilities: Burkina Faso Water Supply and Sanitation Program (P164345); and Haiti Sustainable Rural and Small Towns Water and Sanitation Project (P148970). One project includes antenatal programs, which are covered by hygiene- and sanitation-related behavior change communication (Vietnam); and another project, Angola Health System Performance Strengthening Project (P160948), includes municipalities implementing operational plans for medical waste management.

Menu of options by sector

To support task teams and clients in incorporating interventions into the design and implementation of future operations, this section provides a menu of options, organized by sector, for IPFs, DPOs, and PforRs. These options draw from the evidence review, preceding chapters, and existing and previous operations; however, they are intended to provide a starting point and recognize that interventions in AMR are often one part of an overall loan package, sectoral reform, or wider set of initiatives. Each of the components, performance-based conditions, and prior actions presented below should be seen as a starting point that task teams can adapt, through discussion, with client teams across ministries. In many cases, referencing the existing National Action Plan can help teams identify areas that could benefit from World Bank interventions and financing, and the components can be adjusted and developed further in recognition of a given context or based on consultation with Legal, Procurement, Finance, Environmental and Social, and other teams.

Health sector approaches

COMPONENTS

Strengthening infection prevention and control in clinical settings. This component focuses on a range of stewardship measures to reduce the emergence and spread of infections within hospital settings, and to limit the spread of highly resistant infections among infectious patients. This includes:

» **Hospital surveillance to detect drug-resistant pathogens.** This includes laboratory equipment in regional, hospital, and local laboratories to support the detection of resistant pathogens and training of hospital-based health care and laboratory workers.

» **Health care waste management.** This includes development and enforcement of clinical waste management protocols to safeguard patient safety and reduce the emergence and spread of infections within hospital settings.

» **Private sector and pharmaceutical retail.** This includes the development of regulatory and enforcement mechanisms to facilitate citizens' access to medication. It will include financing the development of regulatory assessments to inform legislative reforms and assessments to determine priorities for improving regulatory enforcement capacity.

Strengthening the capacity to prevent and detect health emergencies at the local, regional, and national level. This component focuses on supporting activities that are needed in the health sector to keep public health threats and global health security threats like AMR from occurring, or keep them from spreading. Activities to improve prevention and detection encompass these activities at country and regional levels, as applicable:

» **Surveillance and collaborative intelligence of AMR at the local, regional, and national level.** This includes providing laboratory equipment and routine consumables in regional, hospital, and local laboratories to support the detection of resistant pathogens, the appropriate use of antimicrobials for health conditions, and training of laboratory workers, microbiologists, physicians, and other health workers.

» **Training and capacity building programming to support health workers in detecting and preventing the spread of AMR.** This includes training health workers on prescribing guidelines and appropriate use of antimicrobials, issuing national guidelines on appropriate use and prescription of antimicrobials (i.e., by using WHO's Essential Medicines List AWaRe classifications[30]), and conducting audits and monitoring to ensure adherence with national guidelines and to track antimicrobial use (AMU).[31] This also includes reducing supply-side gaps, as logistics can ultimately affect prescribing practices.

» **Research into pathogens and other potential causes of AMR.** This includes microbiological, social, and multisectoral initiatives that improve the understanding of the drivers and transmission patterns of AMR across community and health facility settings.

30 The classifications place antimicrobials in three stewardship groups: those to access (antimicrobials with broad uses and relatively lower resistance potential that are recommended for first- or second-line treatment), watch (to be prioritized as key targets of stewardship programs), or reserve (save for last-resort use).

31 Global standards have been established for reporting on two key areas of monitoring, which are collected via the Global Antimicrobial Resistance and Use Surveillance System (GLASS): (i) consumption of antimicrobials, and (ii) the presence or prevalence of antimicrobial-resistant pathogens, resistant genes, or antimicrobial residues. WHO GLASS proposes a master protocol to be used for the generation of reliable estimates of mortality attributable to AMR blood stream infections (BSIs), focused on the two AMR Sustainable Development Goal (SDG) indicators.

» **Community engagement, capacity building, trust building, and risk communication.** Ensuring productive and efficient engagement from and with the community will require a combination of activities focused on capacity building, trust building, and clear risk communication to ensure that communities understand how risk levels ebb and flow and how communities can productively contribute to prevention and detection efforts. This will include working with private, public, and civil society actors and clinical bodies to support the development of information, education, and communication (IEC) messaging and materials. It also includes risk communication with specific subpopulations and will require close collaboration with other sectors dealing with animal husbandry and water and sanitation programs.

» **Strengthening and implementation of dis- and misinformation strategies.** As the COVID-19 pandemic made clear, mitigating the emergence and spread of health threats (such as AMR) relies in part on providing clear, accurate, and easily digestible information about the drivers of epidemics to communities, health workers, and the general public. This includes programming to counter misinformation as well as communication campaigns and materials to build awareness and understanding of relevant risks and good practices.

Guidelines and standards for AMR management. The component will support the development of consistent guidelines and standards for coordination between surveillance institutions, including provisions for sharing public health assets, transferring specimens, and sharing data on disease surveillance and outbreaks. It will provide finance for (i) developing consistent frameworks, standards, protocols, procedures, and guidelines ("standardized frameworks"); (ii) conducting country assessments and evaluating the establishment and performance of surveillance institutions for addressing AMR; (iii) developing protocols to facilitate and support the regional use of laboratories and other public health assets ("supportive protocols"); (iv) adapting regional protocols, frameworks, standards, and guidelines for addressing AMR to promote their adoption at the national level; (v) strengthening technical working groups; (vi) convening an annual conference on AMR surveillance and containment; and (vii) developing and disseminating multisectoral preparedness and response plans.

Infection prevention and control in health care facilities. This component will finance an assessment of infection prevention and control needs in selected health care facilities. The assessment will cover the following areas: staffing needs, microbiology laboratory support, minor civil works that can improve ventilation and air flow, equipment needs, personal protective equipment and decontamination capabilities. Based on the assessment, the component will provide support to the Ministry of Health to develop national guidelines for all health care facilities, including guidelines for highly infectious patients with drug-resistant infections, and to develop and implement infection prevention and control programing in up to five health care facilities. At each of the facilities, the component will support the improved availability of isolation beds and IPC equipment and infrastructure at the point of care, training to support compliance with IPC measures, and audits and quarterly reporting on compliance with national guidelines on IPC practices.

Prescribing guidelines. This component will support efforts to understand prescribing practices and design and implement stewardship programs to prompt a shift in prescribing toward rational prescription in health care facilities. These efforts will be based on an assessment of resistance patterns and clinical syndromes for institutions that do not have guidelines. It will finance equipment to enable the monitoring of antimicrobial use and support the Ministry of Health in conducting an assessment of key areas of irrational prescribing; based on this assessment, it will support the development of updated national prescribing guidelines for antimicrobials.

The stewardship program will focus on secondary/tertiary hospitals and will provide equipment to identify patterns of disease and resistance at each hospital and will provide support during regular ward rounds. It will also support prescription audits and monitoring, health worker training and prescribing consultations, a training program for managerial staff, and a pilot program to reduce surgical site infections in tertiary hospitals through a stewardship program on rational prophylaxis and treatment. Finally, the component will finance the procurement of information technology hardware and software to provide rapid, updated information and guidance on prescribing based on observed symptoms and basic patient medical information.

Public awareness. This component will finance qualitative and quantitative assessments of patient and health worker beliefs about the appropriate use of antimicrobials in human health, and the assessments will consider socioeconomic factors, such as gender. The component will also finance technical assistance to support the design of a public awareness campaign, targeted at the community and health facility level, to change inaccurate beliefs about the use of antimicrobials . To support improvements in awareness at the community level, a classroom module will be developed for dissemination in schools and will be supported by a train-the-trainer teaching module, which will be developed in conjunction with behavior change experts. To target adult populations, the component will also support the development of a radio and billboard campaign highlighting the importance of prudent antimicrobial use and the consequences of irrational antimicrobial use. For the health facility level, public awareness campaigns will include posters, informational sessions, and health worker training. The component will also support dissemination through social media and religious platforms.

Surveillance networks. This component will support the establishment of fit-for-purpose laboratories, transnational surveillance networks, rapid response mechanisms, and other health assets designed to manage AMR risks on a regional or continental scale. This will include the creation and integration of regional surveillance networks, including the creation of an integrated electronic network of regional surveillance platforms. The component will provide financing for (i) the development of a unified IT platform and infrastructure; (ii) technical workshops on selected public health challenges; (iii) transportation and processing of samples for testing at affiliated laboratories; and (iv) the procurement of reagents and specialized materials for sample testing. The subcomponent will also provide technical assistance for the piloting and rollout of a regional AMR scorecard at the national level.

Laboratories. This component will finance (i) the design, construction, equipping, furnishing, and setup of a biosafety level 3 (BSL-3) national reference laboratory, including the establishment of a proficiency testing system and panel production center, a laboratory equipment maintenance center, a biobank center, and a central warehouse; (ii) the construction and equipping of selected reference BSL-2 laboratories at selected locations; and (iii) the equipping of selected BSL-2 regional reference laboratories. These laboratories will become Centers of Excellence in AMR prevention, preparedness, and detection. This component will finance (i) the development and dissemination of AMR tools and policies; (ii) the expansion of a regional AMR scorecard pilot at local and national level; and (iii) capacity building for an AMR network. The data management center will serve as a regional and national hub for data sharing, disease surveillance and reporting, integrated data analysis, evidence translation, and database development.

Electronic information systems. This component will finance (i) the design and development of an electronic information platform and database for AMR intelligence; (ii) the implementation of an electronic distribution list to rapidly disseminate guidance to public health officials and health care providers on emerging threats; (iii) the development and distribution of a periodic report that provides detailed analysis of AMR trends; and (iv) the development of multimedia information products designed to increase public awareness of disease risks and recommended health practices.

Workforce training. The component will support the development of a diverse and skilled cadre of public health workers to fulfill a complex mandate and to ensure that the public health assets described above are fully utilized. The component will finance activities in three key areas: (i) the establishment of partnership agreements with health education institutions to support the development and implementation of AMR training programs; (ii) technical assistance for establishing and operationalizing an AMR fellowship program to build critical skills among entry-level, mid-career, and senior technical staff; and (iii) development and delivery of training for AMR staff on critical skills related to laboratory systems (including occupational health and safety and environmental and social safeguards), disease surveillance, outbreak investigation, emergency response, data management, and risk communication.

Health sector approaches

PERFORMANCE-BASED CONDITIONS AND PRIOR ACTIONS

National strategic planning, budgeting, coordination, monitoring, etc. for AMR management in health care facilities and settings:

- Adoption of a comprehensive/costed National Action Plan (NAP) for AMR (note: several countries have NAPs, but some have not finalized the approval, updating, or costing of the plan; for these countries, the revision and adoption of the national response plan can be a disbursement linked indicator (DLI) or prior action)
- Completion of a Joint External Evaluation (JEE)
- Number of quarterly operational reviews to identify threats and mitigation related to the spread and emergence of AMR, conducted across health care facilities
- Government budgetary actions for AMR detection and mitigation through (i) contingency appropriations; (ii) expenditure reprioritization through reallocations and virements; or (iii) supplementary budgets
- National regulation/legislation[32] to support the detection and mitigation of AMR (supported by budgetary action)

Risk communication, community engagement, and social mitigation:

- Number of behavior change campaigns aimed at health care workers that address the drivers of AMR in community settings
- Improvement in people's knowledge, behaviors, and attitudes related to AMR (using simple phone surveys to assess baselines and improvements thereafter)
- Development and adoption of a national strategy for managing highly infectious patients, i.e., with infections that are drug resistant (e.g., MDR-TB, C. difficile, Vancomycin-resistant Enterococci [VRE], and Carbapenem-resistant Enterobacteriaceae [CRE])
- Number of high-risk persons benefiting from shielding/isolation interventions
- Number of health facilities receiving material support for conducting risk communications

Surveillance and diagnostics:

- Number of AMR surveillance and detection teams established in hospital/regional settings
- Number of sentinel sites established for the detection and surveillance of AMR
- Data platforms established—One Health, laboratory information, antibiotic use
- Number of laboratories with appropriate equipment and staff to detect the top-three resistant pathogens for the country/region

32 A range of agencies may set regulations relevant to antimicrobial production, sale, or use, such as those with oversight of clinical practice, food and drug safety, commerce, imports and manufacturing, or environmental management. Regulations may span a range of issues, such as licensing of new antimicrobials (or alternatives), prescriber qualification requirements versus over-the-counter sale of antimicrobials, limits on the types and amounts of antimicrobials that may be used for certain purposes (including agriculture and aquaculture), quality and labeling requirements, or withdrawal periods after use of medicines in animals before processing for food.

Infection prevention and control:

- Development of IPC guidelines[33] at the national level, which are disseminated to [X] percent of national hospitals
- Number of health workers[34] trained in IPC for AMR prevention
- Number of facilities with IPC monitoring mechanism for AMR detection and prevention
- Number of facilities with WASH facilities

33 Guidelines often include hand hygiene and other WASH interventions, use of personal protective equipment, surface cleaning, waste management, injection safety, limitations on invasive procedures and nonessential inpatient stays, and facility capacity limits to ensure sufficient patient spacing (WHO 2016).

34 Including infection preventionists, who help to maintain a focus on IPC in health care facilities.

Agricultural and food sector approaches

COMPONENTS

Strengthening oversight and monitoring of antimicrobial use in livestock settings. This component will finance the development of prudent use guidelines for different audiences (government officials, professional associations, and facility-level actors). It will also provide support to the government, in particular the government's ability to design and implement enforcement mechanisms, by financing equipment, infrastructure, and training to enable better oversight of AMU in selected settings and promote compliance with prudent use guidelines, such as the restricted use of antimicrobials in food-producing animals. In selected regions, where AMU oversight is weak, the component will finance a package of interventions designed to improve use and oversight. This will include equipment, training, and materials for increased vaccination and use of non-antibiotic feed additives. There will also be a pilot residue-monitoring program to assess compliance with and uptake of the package of interventions.

Strengthening AMU and AMR monitoring in crop production. This component will support the government in establishing an initial infrastructure network to measure AMU and AMR in crop production. It will finance the equipment and materials to establish sentinel sites where crops can be screened for antimicrobial use.

Monitoring of sales and use of antimicrobials in livestock settings. This component will support regulatory agencies in developing systems and infrastructure to better track the sale and use of antimicrobials in terms of class, volume, purpose, setting, and≈dosing to improve understanding of current practices, guide targeted interventions, and detect changes over time. It will provide equipment and training to collect, assess, and record data from samples of diseased animals, which will be screened for resistance at the national state veterinary diagnostic library. It will also support the government in complying with international regulations and initiatives and will enable pairing of resistance and consumption data in support of epidemiological analyses seeking to understand disease patterns.

Assessments to support the development of behavior change campaigns. This component will finance interventions to support the government in efforts to improve understanding and rational use of antimicrobials among farmers, veterinarians, and paraveterinarians. It will finance qualitative and quantitative assessments that will be used to understand existing perspectives and to inform the approach to messaging and awareness campaigns, which will be disseminated through mass media channels.

Early detection of disease outbreaks and laboratory confirmation of the etiologic agents/ pathogens. This component will support enhancement of national surveillance and reporting systems and their interoperability at the different tiers of the health systems, cross-border coordination in the surveillance of priority pathogens and diseases, and timely reporting of human public health and animal health emergencies in line with the International Health Regulations (IHR) 2005 and the WOAH Terrestrial Animal Health Code. This component will strengthen the linkages of surveillance and response processes at all levels of the health system. It will identify and/or establish networks of efficient, high-quality, accessible public health and veterinary laboratories and will also support the establishment of a regional networking platform to improve collaboration for laboratory investigations. It will contribute toward strengthening the capacities of national veterinary and public health laboratories in the areas of surveillance, pathology, diagnosis of priority infectious disease pathogens, and AMR. The four subcomponents of this component are (i) national and subnational surveillance system; (ii) health information and reporting systems; (iii) laboratory diagnosis capacity; and (iv) supply chain management systems.

Integrated disease surveillance infrastructure for cross-sectoral interoperability of surveillance and reporting systems at the country and regional level. This component will support investments in renovating and upgrading existing facilities, ensuring adequate supplies, and strengthening supply chain management. Networking of laboratories will be supported for (i) sharing of timely information across countries; and (ii) contributing to joint investigations of disease outbreaks. Networks will ensure improved capacity to diagnose diseases, identify public health threats, and conduct surveillance. Networks will also serve as effective platforms for learning and knowledge sharing. The component will support strengthening of specimen management, in part by (i) streamlining the laboratory specimen referral process, including through use of subnational laboratories rather than a central laboratory, where possible; and (ii) improving efficiency of specimen transport and disposal systems, including through use of private sector partnerships.

Workforce development and incentives. This component is cross-cutting and aims to strengthen government capacity to plan, implement, and monitor human resource interventions. It will provide support to the development of institutional capacity for workforce training by leveraging existing training structures and programs in the region and other workforce training programs that address critical human/veterinary health needs. It will support analysis to improve the incentive environment within which public health and veterinary health workers operate. This analysis will consider creating incentives that seek to draw those with relevant skills into the public sector and also improve staff motivation and retention, considering gender differences within the health workforce. Viable options will be explored under this component to ensure a centrally coordinated and efficient process for retaining a skilled workforce (in both animal and human health) that is available for routine surveillance and rapid deployment for case detection, laboratory confirmation of suspected cases, vaccine distribution logistics, and delivery of primary health care for common illnesses as part of outbreak response.

Strengthening capacity of national veterinary services. This component strengthens the capacity of national veterinary services to perform their core public good mandate (primarily to prevent and control contagious animal diseases), thereby benefiting all herders and especially pastoralists and agropastoralists. The component will (i) support veterinary services workforce development by regularly updating training plans based on identified gaps in human resources, helping to implement training plans by sponsoring veterinary masters and doctoral degrees and continuing education programs, and establishing private veterinary clinics to provide animal health care services in strategic areas; (ii) support construction or upgrade of essential infrastructure and equipment for veterinary services; field veterinary units or pharmacies, border inspection posts, and vaccination pens; and provide critical equipment; and (iii) improve the management of staff, material resources, disease information, and data collection and analysis by strengthening and maintaining digital databases and tools.

Support to harmonized surveillance and control of priority contagious animal diseases. This component will support (i) the regular updating of National Strategic Plans against these diseases, in line with global and regional strategies and based on respective national capacities and financing available; (ii) the cofinancing of nationwide mass vaccination campaigns, surveillance programs, and necessary equipment needed to reach the highest possible level of protection against priority diseases in the livestock population (based on disease National Strategic Plans); (iii) surveillance and capacity-building programs for other important transboundary animal diseases, including climate-sensitive and zoonotic diseases such as Rift Valley fever and foot and mouth disease; and (iv) laboratory capacity strengthening for the testing and treatment of contagious animal diseases.

Support to control veterinary medicines. To help address growing concerns over the misuse of veterinary medical products (VMPs), particularly antimicrobials, which have wide negative impacts on animal and human health and economies, this component will (i) support the development or improvement and initial implementation of a National Strategic Plan on VMPs, as well as a National Action Plan on AMR, consistent with the global WHO/FAO/WOAH strategy; (ii) help to finance the implementation of surveillance and monitoring plans to ensure the quality of VMPs and reduce antimicrobial resistance (in slaughterhouses, marketplaces, and farms), and (iii) establish more regular inspection campaigns to reduce illegal sales of VMPs, which are virtually unchecked. These plans will include extensive communication activities to increase awareness of these issues in the general population (herders in particular).

Improving livestock producers' access to animal health services. The component will build on the results from the WOAH evaluation under the Performance of Veterinary Services (PVS) Pathway to enhance the long-term capacity of the country to sustainably reduce livestock mortality and other losses caused by animal diseases, thereby increasing livestock productivity and reducing inappropriate reliance on and misuse of antimicrobials. It will improve farmers' access to efficient animal health services provided by both public and private veterinary services under their respective responsibilities (including the "sanitary mandate" for private veterinarians). The component will finance (i) vaccine purchase and delivery as well as vaccination campaigns; (ii) the implementation of a mass communication and sensitization campaign to reach all targeted beneficiaries; (iii) studies on disease prevalence through the National Livestock Laboratory; (iv) rehabilitation of one regional laboratory; (v) strengthening of the National Livestock Laboratory's capacity to assess and advise on AMR and drugs residues; (vi) technical assistance to the General Directorate of Veterinary Services to develop or update animal disease control strategies for dissemination to field veterinarians (prioritizing foot and mouth disease, Newcastle disease, fowl pox, sheep and goat plague (PPR), and contagious bovine pleuropneumonia); and (vii) strengthening of national veterinary services, specifically of surveillance systems, to ensure early reporting, notification, and effective response to disease outbreaks.

Agricultural and food sector approaches

PERFORMANCE-BASED CONDITIONS AND PRIOR ACTIONS

National strategic planning, budgeting, coordination, monitoring, etc. for AMR management in health care facilities and settings:

- Adoption of a multisectoral comprehensive/costed NAP for AMR (note: several countries have NAPs, but some have not finalized the approval, updating, or costing of the plan; for these countries, the revision and adoption of the national response plan can be a disbursement linked indicator (DLI) or prior action)
- Completion of a PVS evaluation
- Number of quarterly operational reviews to identify threats and mitigations related to the spread and emergence of AMR, conducted across network of agriculture sentinel sites
- Government budgetary actions for AMR detection and mitigation through (i) contingency appropriations; (ii) expenditure reprioritization through reallocations and virements; or (iii) supplementary budgets
- National regulation/legislation to support the detection and mitigation of AMR (supported by budgetary action), including phasing out of nontherapeutic use of antimicrobials, and banning the use of the highest priority/critically important antimicrobials in animal and plant health

Risk communication, community engagement, and social mitigation:

- Number of behavior change campaigns aimed at agricultural producers/workers that address the drivers of AMR in community settings
- Improvement in people's knowledge, behaviors, and attitudes related to AMR (using simple phone surveys)
- Development and adoption of a national strategy for managing antibiotic-resistant bacterial diseases in agriculture and aquaculture
- Number of agriculture advisory offices/programs receiving material support for conducting risk communications

Surveillance and diagnostics:

- Number of agriculture AMR surveillance and detection teams established in regional settings
- Number of sentinel sites established for the detection and surveillance of AMR
- Number of laboratories with appropriate equipment and staff to detect the top resistant pathogens that pose potential threats to people

Infection prevention and control:

- Development of IPC guidelines at the national level, which are disseminated to [X] percent of agricultural producers
- Number of agricultural health workers trained in IPC for AMR prevention
- Number of facilities with IPC monitoring mechanism for AMR detection and prevention
- Number of facilities with WASH facilities

Water and environment sector approaches

COMPONENTS

Strengthening water and sanitation infrastructure for health emergency preparedness and response. This component will support preparedness, response, and recovery related to health and disease threats by focusing targeted investments in WASH facilities and waste management in public institutions such as schools and health care facilities and in public places such as markets, transport hubs, etc. It will finance assessments to understand gaps in existing infrastructure, civil works, and renovations so that existing infrastructure can be upgraded in compliance with an appropriate standard and that annual audits can ensure that infrastructure is properly maintained.

Strengthening water, sanitation, and hygiene in health care facilities. This component will support improved infrastructure and the provision of equipment in health care facilities. It will finance interventions to ensure access to minimum water supply, sanitation, and hygiene standards through construction or rehabilitation of infrastructure and efforts to ensure continuity of services. The component will provide equipment and supplies (including water containers) as well as water service (where it does not currently exist) utilizing trucks or carts for water delivery (small containers, sachets, or other pre-packaged water) and water tankers (including adequate water storage for service operators). It will also provide basic sanitation, including construction of latrine blocks equipped with handwashing facilities and a cabin dedicated to hygienic menstrual management in health care facilities. Finally, it will provide support to strengthen medical waste management and disposal systems, including the purchase of an incinerator and training for health care workers and staff on risk communication, proper handwashing, and hygiene and waste management practices for IPC, with dedicated training modules on the safe disposal of antimicrobials. It will also finance the purchase of alcohol-based hand rubs, relevant cleaning and disinfectant materials, sanitation supplies, and IPC/ WASH kits.

Strengthening water, sanitation, and hygiene in health care facilities for patients and health care workers with disabilities. This component will support infrastructure investments for the construction, upgrading, and rehabilitation of water, sanitation, and hygiene facilities in health care facilities as per standard guidelines, with special considerations for gender, disability, inclusion, and climate change adaptation in design of WASH facilities. This component will ensure (i) water supply within the compound of the facility; (ii) improved sanitation facilities that are usable with at least one toilet dedicated for staff, at least one sex-separated toilet, and at least one toilet accessible for people with limited mobility; (iii) functional handwashing facility, with water and soap or alcohol-based hand rubs available at point of care and within five meters of toilets, and with appropriate accommodations for patients with disabilities; (iv) health care waste management facilities for safe treatment and disposal of sharp and infectious waste (incinerator, placenta pit, waste disposal pit), (v) water treatment and safe water storage; and (vi) promotion of hygienic practices in health facilities. Additionally, this component will focus on capacity building through technical assistance to support creation of operation and maintenance plans for constructed facilities as well as development of sanitation service chains. It will also provide capacity building and training to personnel and health care workers and seek the harmonization of WASH information systems across all key participating institutions. Finally, this component will provide support in procurement and contract management for proposed infrastructure to address substandard construction quality.

Strengthening water, sanitation, and hygiene infrastructure in community settings during emergencies and for vulnerable populations. This component will support (i) provision of safe water, targeting the most vulnerable (elderly, refugees/internally displaced people); (ii) promotion of the existing electronic payment systems for water bills to reduce risks of disease transmission; (iii) provision of water and basic supplies (such as soap, personal hygiene products, and other toiletries) to vulnerable people and families; and (iv) emergency support to water supply and sanitation utilities to ensure continuity of water supplies. The component will also support civic authorities in strengthening the availability of WASH stations in business areas and areas of public need such as stations, libraries, and markets; and it will support strategies and partnerships with the private sector to incentivize increased production and provision of hygiene materials.

Strengthening water, sanitation, and hygiene infrastructure in schools. The activity will support schools with essential measures to ensure the safety of pupils, including (i) provision of low-cost water, sanitation, and hygiene equipment, such as water tankers and portable handwashing stations, at all public primary and secondary schools; (ii) provision of hygiene kits, disinfectants, and sanitizers; and (iii) support for school infirmaries, including training on good hygiene practices and prevention measures for infirmary staff.

Strengthening water, sanitation, and hygiene in schools for children and educational staff with disabilities. This component supports infrastructure investments to support the construction, upgrading, and rehabilitation of WASH facilities in schools as per standard guidelines, with special consideration for gender, disability, inclusion, and climate change adaptation in design of WASH facilities. The project will support the construction of toilets in schools in the project area and will coordinate with Ministry of Education to ensure proper maintenance of facilities in schools. School toilets will consist of separate facilities for students: males (one urinal and one toilet for 70 boys) and females (one toilet per 35 to 40 girls and features to support menstrual hygiene management), and separate facilities for teachers. Unlined pit latrines in schools will be converted to energy-efficient dry latrines with regular sludge removal for reuse as fertilizer, thereby contributing to greenhouse gas emission reduction and improving latrine emptying and waste containment and management. Running water will be made available in the toilet, together with handwashing facilities with soap. This component will focus on capacity building through technical assistance to support creation of long-term operation and maintenance plans to finance and maintain WASH services. It will also provide capacity building and training to personnel and teachers and seek the harmonization of WASH information systems across all key participating institutions. Finally, this component will provide support in procurement and contract management for proposed infrastructure to address substandard construction quality.

Community engagement and risk communication. This component will finance a comprehensive behavior change and risk communication intervention by working with private, public, and civil society actors to develop messaging and materials. This component will finance (i) the development of reporting tools; (ii) training for community health workers and volunteers; (iii) the development and testing of messages and materials; and (iv) activities related to the identification and advocacy of key influencers (i.e., religious leaders, celebrities, etc.).

Construction and rehabilitation of WASH facilities and handwashing stations in schools, health facilities, and public places. This component supports increasing access to water supply, sanitation, hygiene, and waste management services for schools, health centers, and other public spaces. The activities to be financed include a full inventory of existing schools and health centers and their current WASH service levels, as well as construction and/or rehabilitation of WASH facilities.

Construction and rehabilitation of WASH facilities in agricultural and fisheries/aquaculture settings. This component will ensure proper WASH infrastructure and practices are in place aboard fishing vessels, landing sites, aquaculture operations, processing plants, and markets so as to protect fish health, provide safe fish and fish products, and reduce the spread of AMR. This component will include provision of safe water supply by ensuring that fisheries and aquaculture workers have access to potable water for drinking, and that water used for ice production is potable water or purified seawater. It will also provide improved sanitation by ensuring access to improved sanitation facilities, with separate facilities for women and girls that are affixed with a lock on the inside and are regularly cleaned, disinfected, and in good working order. Sanitation facilities will also include disposal containers for menstrual management materials, and soap and water for washing. Finally, the component will ensure that (i) a cleaning and disinfection protocol is available and implemented, with materials for cleaning and disinfection available, (ii) handwashing facilities with access to soap and water are available, and staff are trained on procedures for personal hygiene; and (iii) there is proper treatment and management of waste and wastewater.

Strengthening water, sanitation, and hygiene in agricultural settings. This component will ensure that farm owners and workers have adequate access to WASH services with special consideration given to gender, disability, inclusion, and climate change adaptation in design of WASH services. This will include support for (i) clean water; (ii) improved sanitation to reduce the occurrence of open defecation, which includes separate sanitation facilities for women and girls; (iii) handwashing facilities with soap and promotion of good hygiene behaviors to support workers' health, well-being, and productivity; (iv) provision of sanitary and disinfection material; (v) pest prevention and control; and (vi) agricultural wastewater treatment to control pollution from confined animal operations and from surface runoff that may be contaminated by chemicals in fertilizer, pesticides, animal slurry, crop residues, or irrigation water.

Sewerage and wastewater treatment. This component includes activities related to institutional support for sanitation service delivery, alternative sanitation technologies, construction of fecal sludge treatment plants, and more effective wastewater treatment. The objective of this component is to improve wastewater collection and treatment in the project areas and finance all infrastructure works related to wastewater collection and treatment. The component will develop a comprehensive response to the on-site sanitation challenges and support on-site sanitation services and systems in priority areas. In areas where sewers are not feasible or where there are tenurial barriers, such as in low-income settlements, this component will provide alternative sanitation services, including (i) improved sanitation and septage management through upgrading of unimproved toilets in poor households; (ii) construction of a number of Decentralized Wastewater Treatment Systems (DEWATS); (iii) communal septic tanks; (iv) provision of septage services (emptying, transport, and treatment, including leasing of emptying and transport equipment from private operators and a support fund for on-site sanitation facilities); (v) support for the development of fecal sludge management infrastructure and service providers; and (vi) sanitation marketing and hygiene promotion to influence sanitation behaviors. This component will also support capacity building of the water and sewerage utility, including its capacity to respond to climate risks and related impacts and contribute to climate change adaptation actions; this aspect strengthens the social compact between the utility and its users, reduces barriers to the use of communal sanitation facilities among women and girls in tandem with establishing on-site sanitation, increases billing and collection, and supports potential national water sanitation and supply reform initiatives. In addition, disaster planning and response for water and wastewater infrastructure and services will be strengthened through the elaboration of emergency preparedness plans.

Sewerage and wastewater treatment investments to specifically address AMR. This component will establish a national program to improve water, sanitation, and hygiene issues with the focus on improving approaches to addressing AMR, through the following subcomponents:

» **Assessments of the need for on-site and sewered solutions.** This subcomponent will finance a national assessment of context-specific, geographical, and social and economic conditions in high-priority locations and sites for sewered and on-site solutions, to determine the urgency and feasibility of potential investments to address AMR.

» **On-site sanitation solutions.** This subcomponent will finance on-site sanitation interventions in areas where open defecation rates and access gaps are still high and will provide equipment and infrastructure to increase access to toilets and on-site sanitation. It will also finance septic tanks and systems for the effective removal, transport, and treatment of waste.

» **Sewerage networks.** This subcomponent will finance improved connections to existing sewerage networks and to effective treatment in wastewater treatment plans, with primary/secondary/tertiary/advanced treatment levels.[35]

» **Last-mile sludge treatment and disinfection.** To address trace levels of antimicrobials and evidence of resistant bacteria in treated sewage sludge, this subcomponent will finance assessments to determine approaches to the highest-risk areas, once safely managed sanitation is achieved, and will then finance equipment and infrastructure investments to support disinfection to remove trace antimicrobials.

» **Wastewater treatment for highest-risk areas.** This subcomponent will finance advanced treatment solutions for critical municipal wastewater treatment plans and pretreatment solutions for hospitals or antibiotic manufacturing facilities.

» **Surveillance.** This subcomponent will support surveillance and monitoring of AMR and antimicrobial-resistant gene (ARG) levels at sentinel sites to support the government in identifying the effectiveness of sanitation solutions and the need for adjustments.

Nature-based solutions for wastewater treatment. This component supports a range of nature-based solutions, including conventional and high-end constructed wetlands,[36] river re-naturalization, and restoration of wetlands that provide secondary/tertiary treatment of wastewater, enabling removal of contaminants and leading to dispersal of AMR in the environment.

Hygiene behavior change. This component will finance behavior change and communication campaigns at the community level and for farming and aquaculture workers.

» **Behavior change and communication in communities.** This subcomponent will finance a comprehensive behavior change intervention in communities by working with private, public, and civil society actors to support the development of information, education,

35 Wastewater treatment plants are effective at eliminating many pathogens, but they are not typically designed to remove antimicrobial residues or resistant organisms, and so, task and client teams will need to discuss the resulting trade-off—that is to weigh the goal of reducing AMR contaminants (urgency) against the goal of ensuring affordable operating and management costs (feasibility). The higher the goal of removing AMR contaminants, the higher will be the costs and the need for specialized operators.

36 Constructed wetlands can efficiently remove aqueous ARGs, but there is also a risk that they can act as reservoirs for specific ARGs. There is evidence that some ARGs can accumulate in constructed wetland sediments, which can then later be released from sediments to water. In some settings, this type of intervention will be better than no treatment, but evaluating the specifics of the intervention in the proposed setting will be important for the relevant task and client teams.

and communication (IEC) messaging and materials. This will include (i) nationwide campaigns promoting and marketing handwashing, through various communication channels such as mass media and social media; (ii) information and communication activities to increase the attention and commitment of government, private sector, civil society, community leaders, and religious leaders, and to increase awareness, knowledge, and understanding among the general population; and (iii) development of reporting tools.

» **Hygiene and behavior change in farming and aquaculture workers.** This component will finance a comprehensive behavior change intervention in fishing vessels, landing sites, aquaculture operations, processing plants, markets, and fishing communities. The component will promote hygiene behaviors through campaigns, short workshops, and IEC materials. Workshops will be conducted on seafood hazards and on fishery product quality and quality measurement, contamination, and waste management, and will include good hygiene practice requirements for washing, cleaning, handling, and storing fish. Workshops will be supplemented by campaigns and IEC material on personal hygiene, handwashing, and menstrual health and hygiene.

» **Hygiene and behavior change in agriculture.** This component will finance a comprehensive behavior change intervention in farms and agricultural communities. It will support the development of IEC messaging and materials. Trainings will be conducted on basic cleaning and disinfection, isolating animals to prevent spread of infectious germs, pest prevention and control, and waste management and disposal. This will be supplemented by campaigns and IEC material on personal hygiene, handwashing, and menstrual health and hygiene.

Strengthening AMR surveillance and monitoring in wastewater systems. This component will build local capacity to perform wastewater testing for AMR. The main activities will focus on building capacity for sample analysis, improving data management, and building capacity for surveillance. This component will include the following subcomponents:

» Providing support to water and sanitation utilities to implement routine surveillance, detection, and reporting of AMR

» Strengthening laboratory capacity to perform wastewater testing; establishing networks of efficient, high-quality, accessible public health, veterinary, and private laboratories for the diagnosis of AMR and infectious human and animal diseases; and establishing a regional networking platform to improve collaboration for laboratory investigation

» Improving data management by (i) strengthening the competencies of laboratory personnel to analyze and use laboratory surveillance data; (ii) strengthening laboratory data management systems to report more effectively; and (iii) achieving interoperability between data management systems, where possible

» Training and capacity building, including training to develop human resource capacity in surveillance, preparedness, and response

Water and environment sector approaches

PERFORMANCE-BASED CONDITIONS AND PRIOR ACTIONS

Risk communication, community engagement, and social mitigation:

» Number of (district/community level) WASH officers trained on the drivers of AMR in community settings

» Number of people reached with hygiene behavior change campaigns for IPC

Surveillance and diagnostics:

» Number of wastewater treatment plants implementing routine surveillance, detection, and reporting of AMR

» Number of water utilities implementing routine surveillance, detection, and reporting of AMR

» Reporting mechanism for AMR in water and sanitation systems established and in use

Infection prevention and control:

» National program on water supply and sanitation developed to improve access to water supply, sanitation, and hygiene in communities, schools, and health care facilities

» National hygiene awareness and behavior change campaign developed

» Number of people provided with access to improved water supply, sanitation, and handwashing facilities under the project

» Number of health care facilities with functioning water, sanitation, hygiene, and waste management services

» Development of medical waste management and disposal guidelines at the national level, which are disseminated to [X] percent of health care facilities/water and sanitation utilities

» Issuance of regulations/legislation on treatment requirements, including disinfection for public water systems that prevent pathogens from contaminating drinking water and wastewater

» Issuance of regulations/legislation on treatment and disposal of sewage and wastewater to mitigate spread of AMR

References

WHO (World Health Organization). 2016. Guidelines on Core Components of Infection Prevention and Control Programmes at the National and Acute Health Care Facility Level. Geneva: World Health Organization. Guidelines on core components of infection prevention and control programmes at the national and acute health care facility level (who.int).

Chapter 5
Implementation Guidance for Investing in Interventions to Address AMR through World Bank Operations

Early and detailed attention to implementation arrangements is beneficial for the success of interventions to address AMR.

Chapter 5
Implementation Guidance for Investing in Interventions to Address AMR through World Bank Operations

Chapter 5 summary

Early and detailed attention to implementation arrangements is beneficial for the success of interventions to address antimicrobial resistance (AMR), and this two-part chapter draws on World Bank operations and other projects and country experiences. Implementing interventions to address AMR can be challenging, not least because they can involve collaboration across multiple organizations and sectors. The first part of this chapter draws on experiences from World Bank operations within and across sectors to provide examples of different implementation arrangements that task teams and countries can adopt. The second part goes beyond the World Bank's engagement through three country case studies, which explore successes and challenges in addressing the AMR agenda in Indonesia, Tanzania, and Nigeria.

As of 2023, the World Bank had more than 60 operations addressing AMR, and these provide a range of experiences to support the design and implementation of new operations. Many projects have strengthened national coordination bodies, which allow for multiple agencies—within a sector and across sectors—to be informed and have a stake in a project's success. Identifying senior advocates and high-level supporters from presidential and prime ministerial offices has also benefited implementation, by ensuring that the AMR agenda is elevated and prioritized, and by providing neutrality between ministries. In addition, given that AMR is not confined by geographical boundaries, projects have drawn on regional mechanisms, both to support technical delivery and to receive and coordinate financing and project management.

The three case studies in the second part of the chapter exemplify multisectoral and single-sector implementation initiatives using a One Health approach to build AMR surveillance and laboratory capacity. They likewise offer important examples for AMR stakeholders. Indonesia has adopted an AMR National Action Plan (NAP) and is collaborating with international organizations to strengthen its surveillance and laboratory capacity, though it still faces challenges such as lack of coordinated multisector working groups and limited laboratory capacity and expertise. In Tanzania, the AfyaData project, which includes an app for data collection, a web-based server for mapping and analysis, and a disease-prediction and decision-making repository, has been successful in building community-led AMR surveillance capacity. Despite facing various challenges, Nigeria is implementing a national AMR surveillance network, leveraging partnerships and international collaborations, involving multiple sectors, and utilizing community-led surveillance to generate real-time data on AMR.

Introduction

Mechanisms can be adopted to support regional and national coordination of efforts to address AMR; such coordination helps ensure that initiatives benefit from strong technical guidance and that implementation approaches draw together relevant parties. Institutional and implementation setups for addressing AMR vary across diverse regional and national environments, but a common challenge concerns the level of coordination required (Box 5). To help address this, client and task teams have drawn on several mechanisms to support coordination at the regional and national levels. This chapter provides examples from World Bank operations implementing AMR-sensitive interventions—the Regional Sahel Pastoralism Support Project (PRAPS), the East Africa Public Health Laboratory Networking Project, the Africa Centres for Disease Control and Prevention (CDC) Regional Investment Financing Project, and the Regional Disease Surveillance Systems Enhancement (REDISSE) project (Phases 1–4)—and draws on key themes and guidance from previous and current task team leaders.

Box 5. Common Challenges for Multisectoral Implementation on AMR

Diversity of stakeholders: Multisectoral collaboration involves bringing together stakeholders from various sectors, such as health care, agriculture, veterinary, environmental, and policy making. Coordinating and aligning their interests and priorities can be complex.

Fragmentation: Different sectors may have their own strategies, policies, and regulations regarding AMR. Overcoming fragmentation and establishing cohesive approaches can be challenging.

Communication and language barriers: Experts from different sectors may use jargon and language specific to their field, making communication difficult. Effective communication and understanding between sectors are crucial for success.

Power imbalance: Certain sectors may have more influence or resources than others, leading to power imbalances that can hinder effective collaboration and decision-making.

Conflicting priorities: Each sector may have its own pressing issues and priorities, which could compete with AMR initiatives for attention and resources.

Policy and regulatory differences: Sectors might have different regulatory frameworks and policies that can create conflicts when implementing joint strategies to combat AMR.

Data sharing and privacy concerns: Sharing data across sectors is vital for a holistic understanding of AMR, but concerns over data privacy and confidentiality can hinder cooperation.

Resource constraints: Some sectors, especially in low- and middle-income countries (LMICs), may lack adequate resources, infrastructure, and capacity to actively participate in multisectoral efforts.

Resistance to change: Adapting to new ways of working and collaborating can be met with resistance from institutions accustomed to working within their sector's boundaries.

Accountability and responsibility: Determining responsibility and accountability in a multisectoral setting can be challenging when issues arise or when measuring the impact of interventions.

Time and coordination: Multisectoral efforts require substantial time and effort to coordinate and align strategies, which may slow down decision-making and implementation.

Monitoring and evaluation: Establishing common monitoring and evaluation frameworks to assess the impact of multisectoral interventions can be complex, especially given the diverse nature of involved sectors.

Political will and leadership: Multisectoral efforts often require strong political will and leadership at the highest levels to overcome challenges and ensure sustained commitment.

Long-term sustainability: Ensuring the continuity of multisectoral collaboration beyond short-term initiatives is crucial for effectively combating AMR over time.

Source: Joshi et al 2021.

For multicounty operations, project design has often drawn on guidance from the Independent Evaluation Group (IEG). According to current and previous task team leaders, important project enablers include drawing on and strengthening existing implementation structures and clearly defining roles and responsibilities. To facilitate project success, the IEG advises that projects rely on "national institutions for execution and implementation of program interventions at the country level, and on regional institutions for supportive services that cannot be performed efficiently by national agencies, such as coordination, data gathering, technical assistance, dispute resolution, and monitoring and evaluation" (IEG 2007, 34). This guidance is reflected in implementation experience across projects, and task team leaders have noted that multisectoral efforts were much more likely to achieve their aims if implementation arrangements were anchored in existing structures. Similarly, soliciting leadership from existing networks or mechanisms is more likely to result in sustained action. Many project examples also demonstrate that clearly defining institutional roles and responsibilities within projects has helped participating institutions to understand how project activities interact with their own mandates as well as other regional and national development priorities.

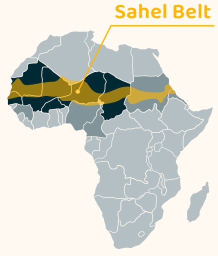
Many projects have also used Memoranda of Understanding (MoUs), terms of reference, and technical and subsidiary agreements to provide entities with clear expectations when embarking on shared agendas. MoUs can help ensure that all parties rely on the established conditions to cooperate effectively, provide any agreed financial or human resources, and share information. Projects have shown that these agreements are useful for setting out an agreed approach for cooperation on research, implementation, and stakeholder engagement, as well as for establishing a regular, efficient flow of data and data analysis. For multicountry projects, these agreements have typically been drawn up between the regional-level agencies and participating countries, as well as between stakeholders at the national level.

National institutional arrangements

National coordination mechanisms can be helpful for enabling collaboration within and across sectors. The Regional Sahel Pastoralism Support Project, for example, draws on multiple national coordination mechanisms. It provides US$248 million in financing across five components: (i) animal health improvement, (ii) natural resource management enhancement, (iii) market access facilitation, (iv) pastoral crisis management, and (v) project management and institutional support. At the national level, PRAPS has several institutional arrangements, including National Steering Committees (NSCs) and Technical Committees (TCs), National Project Coordination Units (N-PCUs), and Results Monitoring and Evaluation Arrangements. Each participating country has established an NSC and TC to serve as monitoring bodies for exchange, guidance, and implementation. Relevant line ministries (particularly those aligned with the livestock agenda of the country) participate in the NSC/TC; they advise on strategic planning and implementation and engage in supervision at the national level. N-PCUs have been established within selected ministries in each country to support the implementation of project activities, and the Committee for Drought Control in the Sahel (CILSS) is responsible for coordinating the monitoring and evaluation (M&E) function. Box 6 provides further details.

Box 6. Regional Sahel Pastoralism Support Project

Regional Sahel Pastoralism Support Project



Project overview

The Regional Sahel Pastoralism Support Project is a multifunctional initiative to strengthen the resilience of pastoralists in the Sahel. With a focus on productivity improvements and the sustainability and resilience of assets for pastoral existence, PRAPS has brought together the private sector, pastoral organizations, advanced research institutes, and national, regional, and international stakeholders to collaborate on a range of coordinated solutions. Since 2014, the project has been implemented in the six countries of the western Sahel belt (Burkina Faso, Chad, Mali, Mauritania, Niger, and Senegal).

Program implementation for PRAPS is coordinated regionally by the Permanent Interstate Committee for Drought Control in the Sahel (CILSS), under the political leadership of the Economic Community of West African States (ECOWAS) and the West African Economic and Monetary Union (WAEMU). Through its project oversight and coordinating role, CILSS has responsibility for executing strategic decisions to ensure the continued coherence between the program support priorities and sector development and regional pastoralism development priorities.

Overview of institutional arrangements

- Regional Steering Committee (RSC). A Regional Steering Committee was established to replace the project's initial Regional Task Force on Pastoralism. The RSC is in charge of coordinating and facilitating cross-boundary interventions; it provides a platform for technical assistance, M&E, training, knowledge sharing, and communication, and it supports policy dialogue with countries for regional alignment and harmonization. The RSC comprises representatives of technical ministries, civil society organizations, and the CILSS.

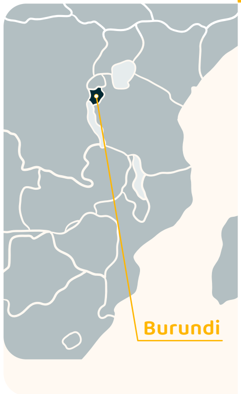
- National Steering Committees and Technical Committees. Each participating country has established an NSC and a TC to serve as bodies for exchange, guidance, and implementation monitoring. Relevant line ministries (particularly those aligned with the livestock agenda of the country) participate in the NSC/TC, advise on strategic planning and implementation, and engage in supervision at the national level.
- National Project Coordination Units. In each country, N-PCUs have been established within selected ministries to support implementation of project activities. N-PCUs also have responsibility for implementation supervision, proposal preparation, project financial management and procurement, M&E, and reporting.
- Results monitoring and evaluation arrangements. Monitoring and evaluation for PRAPS is structured to take place at both the regional and country levels. The CILSS has the overall responsibility for coordinating the M&E function, including the design and implementation of data collection efforts and a data quality assurance mechanism, the review of evaluation and progress reports from participating countries, and facilitation of cross-country learning. At the national level, countries produce monitoring data against established targets, generate information on project progress, and document and disseminate key lessons.

Source: World Bank 2015.

The East Africa Public Health Laboratory Networking Project is another project that has drawn on national and regional mechanisms. It provides US$113.66 million in financing through three components: (i) laboratory networking for specialized diagnostic services and disease surveillance preparedness; (ii) training and regional capacity building to undertake specialized tests to diagnose tuberculosis (TB) and communicable diseases; and (iii) joint operational research and knowledge-sharing activities. It is implemented by the East, Central and Southern African Health Community (ECSA-HC), which is based in Arusha, Tanzania. ECSA-HC has overall responsibility for coordinating activities under the project; at the country level, the responsible entity is the Burundi Ministry of Public Health. Additional institutional arrangements include the National Steering Committee, Project Management Unit, and Results Monitoring and Evaluation Arrangements, which aim to ensure effective implementation, oversight, and monitoring of the project. Box 7 provides further details.

Box 7. East Africa Public Health Lab Networking Project: Burundi

East Africa Public Health Lab Networking Project: Burundi



Project overview

The East Africa Public Health Lab Networking Project was established to support the development of a network of high-quality cross-country public health laboratories within East African Community member states to serve as surveillance sites to monitor disease transmission. Specifically, the laboratory network aims to enhance access to diagnostic services, contribute to disease surveillance, and serve as a platform for training, research, and knowledge sharing. One component of the project aims to strengthen capacities for the diagnosis and surveillance of TB and other communicable diseases.

The East, Central and Southern African Health Community (ECSA), based in Arusha, has overall responsibility for coordinating activities under the project. At the country level, the Burundi Ministry of Public Health has responsibility for the project.

Overview of institutional arrangements

- Regional Advisory Panel (RAP). ECSA-HC put in place a Regional Advisory Panel to serve as a platform for multicountry and multistakeholder expert engagement and dialogue. The RAP is a forum for the participating countries and their implementing partners to report on overall program progress and to share scale-up experiences and lessons. The RAP reviews periodic reports from technical partners—including the World Health Organization (WHO), TB Union, the US Centers for Disease Control and Prevention, and the Tuberculosis Control Assistance Program of the United States Agency for International Development (TB-CAP/USAID)—that offer ongoing technical support, program coordination, and regional learning. RAP also provides support for the establishment of working groups in each thematic area. It comprises officials from each participating country, the East African Community chair, and representatives of WHO, USAID, and other implementing partners.
- National Steering Committee. Under the guidance of the permanent secretary of the Ministry of Public Health of Burundi, an NSC was established to review and approve implementation plans. The NSC comprises the head of surveillance and representatives from the National Reference Laboratory of the National Institute of Public Health, WHO, and other implementing partners.
- Project Management Unit. The Project Management Unit is housed within the Ministry of Health, and contributes to the preparation of consolidated technical and financial reports quarterly and annually. Burundi's minister of public health has overall responsibility for the project, while the permanent secretary is responsible for its technical oversight. Project activities are undertaken by a team consisting of a project manager, an epidemiologist, a microbiologist, and an accountant.
- Results monitoring and evaluation arrangements. Like other countries participating in the East Africa Public Health Lab Networking Project, Burundi has relied on a common framework for monitoring performance of the project, which is regionally coordinated by ESCA-HC. At the national level, Burundi's Ministry of Health designates an M&E specialist responsible for overseeing data collection and quality assurance processes. The specialist also participates in technical reviews, as well as the review of consultant reports or analytical products for M&E.

Source: World Bank 2012.

In many instances, coordination across the human health, animal health, and environment sectors has proven to be challenging. To mitigate these challenges, countries can establish interagency coordination committees (or AMR or One Health committees) composed of representatives from relevant ministries and institutions, particularly those with links to the country's health security agenda. These committees can play a role in making multisectoral decisions on strategic planning and implementation and can guide the development of standard operating procedures, as well as conduct the review of M&E plans and structures. These committees often meet two to four times a year.

The ministries and institutions participating in the National Steering Committee vary; however, commonly participating ministries and institutions include the ministries of health, agriculture, forestry, and food security as well as environment, with support from partners such as the Food and Agriculture Organization of the United Nation (FAO), WHO, and the US CDC. Among the participating ministries and institutions, the ministry that oversees implementation often takes the role of an anchor ministry; it acts as secretariat to the national coordination committee and engages various stakeholders, including development partners, civil society organizations, and technical experts, among others. Projects can achieve stronger political commitment and convening power if they can draw upon a high-level official, such as the minister of the anchor ministry or a representative from presidential or prime ministerial offices or cabinet secretariat, to serve as the chair for the National Steering Committee.

Some World Bank operations have used effectiveness conditions to secure appropriate implementation arrangements. These conditions have required that countries pass legislation or put in place processes to establish or support an overarching entity or agency that will guide implementation at the national level. These entities often reflect the structure of a public health institute and have been housed in an anchor ministry (such as the ministry of health), with close collaboration with other relevant ministries working on the AMR agenda. The agency has responsibility for coordinating the implementation of various project components by sectoral ministries (agriculture, livestock, health, environment, etc.), nongovernmental organizations, and other stakeholders. The implementing agency comprises National Project Coordination Units and Project Implementation Units that take on cross-cutting functions, including working across sectors to improve efficiency and alignment in the implementation of project activities, transferring and monitoring the use of funds by other implementing ministries and partners, and handling procurement, cross-stakeholder communication, and M&E, as well as generating national progress reports. Given the granularity of project implementation, some projects have put in place subnational coordination mechanisms to support and monitor implementation at field level.

Regional institutional arrangements

Many projects use established regional agencies to guide regional implementation and to coordinate and communicate on important actions in line with the regional agenda. Regional implementing agencies have provided regional oversight and have supported the execution of project components. Projects have typically created regional implementation units that have responsibility for day-to-day administration of regional activities, procurement, financial management, and programming as well as monitoring and evaluation. To help ensure that regional bodies are well positioned for this role, several projects have sought to strengthen the implementation capacity and processes of regional implementing agencies. Projects have also provided technical and investment support to enhance expertise across the project management cycle.

Options for regional governance (such as regional steering committees) can leverage One Health structures to ensure the participation, leadership, and representation of the human, animal, and environmental health sectors of participating countries. These mechanisms have been anchored in regional implementing agencies through their roles as project secretariats. Steering bodies are typically tasked with shaping, overseeing, and monitoring AMR-related activities across countries and sectors for systematic and comprehensive implementation, and reflect multidisciplinary and cross-sectoral action. These mechanisms have also leveraged technical working groups with clear terms of reference to provide technical oversight during implementation, and they are responsible for the review and finalization of operational plans that include priority activities, implementation arrangements, detailed budgeting and costing, data collection timelines, and reporting methods. These steering bodies have also served as platforms for multicountry and multistakeholder engagement, dialogue, and information sharing.

The Africa CDC Project is a US$200 million project that includes activities to address AMR and that draws on coordination mechanisms to enable progress across its three implementing agencies. The project provides financing through five components: (i) governance, advocacy, and operational frameworks; (ii) public health assets; (iii) human resource development; (iv) project management support; and (v) a Contingent Emergency Response Component (CERC) for Ethiopia and Zambia. Its three implementing agencies are the Africa CDC and the Ethiopian and Zambian governments. In addition, the Ethiopia Public Health Institute and the Zambia National Public Health Institute serve as dedicated national-level institutions for coordinating public health interventions. Box 8 provides an overview of the institutional arrangements.

Box 8. Africa CDC Regional Investment Financing Project

Africa CDC Regional Investment Financing Project

Project overview

The Africa Centres for Disease Control and Prevention Regional Investment Financing Project was established to strengthen continental and regional infectious disease detection and response systems. The Africa CDC provides all 55 African Union (AU) member states with training and legal and administrative support to facilitate a harmonized and cooperative approach to disease surveillance and response across countries. In addition to the CERCs for Ethiopia and Zambia, the Africa CDC provides project-funded emergency assistance during disease outbreaks by facilitating the shipment of samples to project-supported laboratories in Ethiopia.

Overview of institutional arrangements

- Ethiopian and Zambian Ministries of Health (MoHs) and National Public Health Institutes (NPHIs). The Ethiopian and Zambian MoHs are the primary implementation agencies; the NPHIs serve as technical entities for coordination and implementation. In each country, the NPHI also provides technical and financial reports to the MoH and the World Bank. In Ethiopia, the state minister for programs is responsible for the execution of project activities, and the Ethiopian Public Health Institute reports directly to the state minister. In Zambia, the permanent secretary for administration and the permanent secretary for technical services are responsible for managing project activities.
- Project Implementation Units (PIUs). PIUs were established at the Africa CDC and the Zambian MoH to carry out the day-to-day project activities. The PIUs include technical staff and operational staff for the management of fiduciary responsibilities and compliance with legal, environmental, and social safeguards. In Ethiopia, the Grant Management Unit (GMU) of the MoH's Partnership and Cooperation Directorate is responsible for the day-to-day management of activities. The PIUs and GMU have the flexibility to recruit specialized technical staff as needed, and some activities may be outsourced to third parties through contract agreements acceptable to the World Bank.

- **The Project Technical Steering Committee.** The Project Technical Steering Committee includes the director of the Africa CDC, the heads of the Ethiopian and Zambian NPHIs, and representatives of the agriculture and livestock sector, as well as representatives of regional projects such as REDISSE. The committee also draws on experts and specialists on an ad hoc basis. It meets at least twice a year to review and finalize annual work plans, review implementation progress, provide technical guidance to the implementing agencies, and share information among relevant stakeholders. Representatives from the agriculture and livestock sectors as well as other regional projects—such as the East Africa Public Health Laboratory Networking Project, Southern Africa Tuberculosis and Health Systems Support Project, and REDISSE—participate in the annual meetings to ensure coordination and harmonization among the continent's various regional projects on surveillance and laboratory networks. The Africa CDC serves as the secretariat, and the committee's activities are guided by terms of reference that clearly define its functions, responsibilities, and collaboration with the Africa CDC, Southern Africa Regional Collaborating Centre, and NPHIs from both countries.
- **Country Steering Committees (CSCs).** In each country, a CSC oversees implementation of the project subcomponents for which the country is responsible. The CSCs include representatives from the ministries of health, agriculture, livestock, and finance as well as from academia and civil society. The composition of the CSC in each country reflects country circumstances and preferences. The primary mandate of the CSCs is to monitor the functions of the implementing agencies at the country level, review annual work plans and implementation progress, provide technical guidance, support the MoHs and NPHIs, and facilitate information exchange among project stakeholders. Technical working groups, subcommittees, and other standing or ad hoc groups have been put in place at the MoH and NPHI level to carry out activities within particular areas of the project operations.
- **Results monitoring and evaluation arrangements.** In each country, monitoring against the results framework is conducted by the PIUs at the country level. PIUs have collected and compiled data related to the Project Development Objective and intermediate indicators, and have produced progress reports on a monthly, quarterly, semiannual, and annual basis—with a semiannual report produced for the World Bank. For each country, an external independent evaluation to assess overall outcomes and effectiveness is planned for 2026.

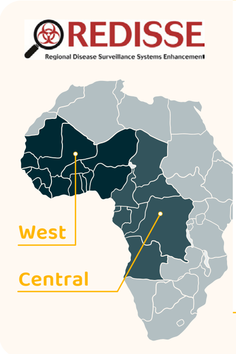
Source: World Bank 2019.

The Regional Disease Surveillance Systems Enhancement project has used steering committees to facilitate collaboration across countries. Over seven years, US$657 million in financing has been structured through five components: (i) surveillance and health information; (ii) laboratory capacity strengthening; (iii) preparedness and emergency response; (iv) human resource management for effective disease surveillance and preparedness for epidemics; and (v) institutional capacity building, project management, and coordination and advocacy. In Central Africa, these components of REDISSE have been expanded to include (i) strengthening of surveillance and laboratory capacities to rapidly detect epidemics; (ii) strengthening of emergency planning and management capacities to respond quickly to epidemics; (iii) human capacity development in public health for effective disease surveillance and epidemic preparedness; and (iv) institutional capacity building, project management, coordination, and advocacy.

Program implementation is coordinated at the regional level by the West African Health Organization (WAHO), an affiliate institution of the Economic Organization of West African States (ECOWAS) that also serves as the program secretariat. WAHO has established agreements with the WHO Regional Office for Africa, the World Organisation for Animal Health, the Regional Animal Health Center, the Centre for International Cooperation in Health and Development, and Fondation Merieux to assist with regional-level activities and provide technical support to participating countries. In Central Africa, the Economic Community of Central African States (ECCAS) Commission is the primary implementing agency. Box 9 provides more details on the implementation arrangements.

Box 9. Regional Disease Surveillance Systems Enhancement Project: Phases 1–4

REDISSE



Project overview

The REDISSE project supports the development of regional platforms and country-specific operations for disease surveillance and response capacity in West and Central Africa. REDISSE has been designed as an interdependent series of projects and is being implemented in phases. Since 2016, four REDISSE projects have provided WAHO with financing for regional coordination and regional activities, and they have provided 16 ECOWAS and ECCAS member states with country-specific financing.

Overview of institutional arrangements

- Project Coordination Units (PCUs). Existing or newly created PCUs in participating countries' ministries of health have responsibility for the technical and fiduciary execution of the project and the day-to-day coordination, implementation, and communication of project components and results. In most participating countries, the PCUs have comprised a project coordinator, an accountant, a social safeguard specialist, an environment specialist, an M&E specialist, and a procurement specialist.
- Regional Steering Committee. A Regional Steering Committee was established to oversee overall project governance. The RSC includes representatives of participating country ministries. The RSC meets twice a year and has primary responsibility for the technical coordination of REDISSE projects. Within the RSC, a regional implementation unit was created to oversee day-to-day administration of regional activities, procurement, financial management, and programming as well as M&E at the regional level.
- National Steering Committees. In each country, multisectoral One Health National Steering Committees have been created to oversee implementation of country-level activities, as well as to review annual work plans and budgets, monitor project progress, and approve annual project reports. The NSCs include representatives from the ministries of livestock, economy and finance, education, agriculture, security, environment and sustainable development, and communications, and from local, regional, and global partners. The NSCs meet twice a year to define project implementation strategies and validate annual work plans and budgets.

- **Results monitoring and evaluation arrangements.** M&E is undertaken at the regional level by implementing agencies; at the country level it will be undertaken in conjunction with external partners such as WHO, US CDC, and WOAH. WAHO and ECCAS have overall responsibility for coordinating the M&E function of REDISSE projects in West and Central Africa, including the design and implementation of data collection efforts that are best done at the regional level; they are also responsible for the provision of technical backstopping on M&E at the country level. Other coordination functions include the development of data quality assurance mechanisms, the collection of data, and facilitation of cross-country learning.

Source: World Bank 2016.

Takeaways

Early and detailed attention to implementation arrangements can be beneficial given the complexities of addressing AMR within and across sectors and across national boundaries. The projects reviewed for this section offer some important lessons on how task and client teams can establish effective approaches for new operations. Multisectoral and intersectoral actions for AMR-related projects such as the Regional Sahel Pastoralism Support Project demonstrate that coordination must take place horizontally across sectors as well as vertically at regional, national, subnational/subregional, and local levels. This includes clearly defining roles, responsibilities, and accountability at all levels.

For leveraging capacity, minimizing costs, and accounting for established relationships, drawing on existing institutions and reporting structures has many benefits. In the reviewed projects, institutional capacity building has comprised a primary component of implementation support provided by the World Bank. In addition to investments to enhance implementing agencies' capacity for financial and project management, efforts have also been directed at understanding the political ecosystem, managing relationships and conflicts between stakeholders, distributing leadership, and providing incentives for institutions and individuals to collaborate. For AMR, these efforts may require a clear understanding of the types of political settlements that are in place, as well as the policy change required over time.

Promoting greater awareness and ownership of the AMR agenda among influential stakeholders could help consolidate multisectoral action and ensure adequate resourcing within current institutional arrangements. Anchoring the AMR agenda within supra-sectoral bodies such as the Office of the President or Office of the Prime Minister may present avenues for promoting greater ownership of the AMR agenda through key stakeholders and political champions. This is also a way to enhance mechanisms for transparency and accountability.

Implementation can benefit when decisions are made and activities are carried out at the highest relevant geographic level. The PRAPS and REDISSE projects have highlighted the use of the subsidiarity principle, a mechanism for guiding the appropriateness of and responsibility for activity implementation within the optimum geographic context—at the subnational, national, or regional level. Under this guiding principle, participating countries were responsible for delegating regional-level activities to the regional implementing agency and for defining activities they deemed most suitable for the country level.

Successful projects have simplified their monitoring and evaluation arrangements and processes to the extent possible. In establishing baselines and targets, project results frameworks could benefit from early focus on and adequate consideration of country contexts. Projects such as the PRAPS call for monitoring and evaluation to be streamlined and realistic.

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Three implementation case studies

This part of the chapter examines how three countries, in partnership with various organizations, have tackled AMR through surveillance, training, and technology. The case studies present the implementation experiences of Indonesia, Tanzania, and Nigeria, highlighting the unique challenges and approaches taken in each country. They provide an overview of current AMR circumstances within each country, specific challenges being addressed, and actions being taken to respond to AMR. The case studies also outline implementation arrangements, enablers of progress, challenges, and barriers to success. Key takeaways for the benefit of teams and other countries planning to implement similar or related interventions are also included.

Case Study 1
Indonesia

Indonesia:
Supporting the development of a One Health surveillance system for AMR

Summary

Over the past decade, increasing levels of drug-resistant infections made it urgent for countries in Asia to address antimicrobial resistance via a multisector collaboration. Indonesia has adopted a One Health approach focused on understanding the burden of drug-resistant infections and their impact on livelihoods. The country has focused on building its AMR surveillance and laboratory capacity across the human, animal, and environmental sectors. This effort has been executed through engagement with international stakeholders and organizations, such as WHO and the Fleming Fund, and through coordinated action across several Indonesian ministries. This case study provides an overview of current AMR circumstances within the country, specific challenges being addressed, and actions being taken to respond to AMR. Existing surveillance implementation arrangements, such as the Tricycle Project, are described, along with factors that have enabled progress and factors that have been a barrier to success. Key takeaways for the benefit of other teams planning to implement similar or related interventions are also included.

Country context

Indonesia is the largest economy in Southeast Asia (Index Mundi 2021) and has reduced poverty by investing in health care and public health provisions, including provisions to address AMR. Indonesia is poised to lead the way in addressing AMR, in particular AMR surveillance and laboratory capacity issues, following its G20 2022 presidency and plans to focus efforts on two priority issues, Global Health Architecture and Digital Transformation.[37]

The first Indonesian AMR National Action Plan was implemented in 2017 (Rencana Aksi Nasional 2017-2019), and focused on the need for more robust and coordinated surveillance efforts throughout the country (Dewi et al. 2021; Gani and Budiharsana 2019; Chua et al. 2021; Sivaraman and Parady 2018). In 2021, building on the work achieved during NAP 2017–2019,

37 G20, "G20 Presidency of Indonesia–Issue Priorities," https://g20.org/g20-presidency-of-indonesia/#priorities.

Case Study 1 **Indonesia**

Indonesia approved a new AMR NAP for 2020–2024.[38] The draft was developed in consultation with multiple sectors, represented by the Ministry of Health, Ministry of Defense, National Agency of Drug and Food Control, Ministry of Agriculture, Ministry of Marine and Fisheries, Ministry of Environment and Forestry, professional and community organizations, and private stakeholders. According to the 2021 Tripartite AMR Country Self-Assessment Survey, or TrACSS, Indonesia ranks its NAP progress with the highest rating possible.[39] The country has strived to secure a budget for AMR NAP implementation and develop functional multisector working groups that are actively and jointly responsible and accountable for addressing common AMR objectives with a One Health approach. During the first wave of COVID-19, the unprecedented demand for laboratory testing saw an expansion of the COVID-19 referral laboratory network to include 685 laboratories in 34 provinces. The successful scale-up was made possible due to cross-ministerial collaborations that brought together expertise and capacity to respond to the health emergency. Although much of the information regarding AMR levels in Indonesia is still limited to a patchwork of areas with laboratory capacity and expertise, the infrastructures and multisector working collaborations initiated during the pandemic have undoubtedly laid the foundations for the future response to AMR in the country.

In a bid to strengthen surveillance efforts across all sectors, Indonesia was selected by WHO to participate in the Tricycle Project. The global integrated survey on extended-spectrum beta-lactamase (ESBL)-producing E. coli, or the Tricycle Project, aims to strengthen AMR surveillance systems and to promote integrated surveillance across human, animal, and environmental sectors. In 2019, Indonesia enrolled in the Global Antimicrobial Resistance and Use Surveillance System (GLASS) and by 2020 had established at least 20 surveillance sites, 16 of which regularly provide data to GLASS (WHO 2021b). Implementation of antimicrobial stewardship programs and multidisciplinary antibiotic awareness campaigns have also become more widespread, and some tangible policies have been enacted. Such projects will inform ongoing activities in Indonesia to assess the AMR burden and to continue developing surveillance capacity.

Specific challenges

The development of the initial Indonesia AMR NAP was supported by a situation analysis conducted in 2016, which highlighted the multisector collaboration within Indonesia as well as several gaps and challenges (Parathon et al. 2017). Misuse and overuse of antimicrobials were identified as the driving forces of AMR across several sectors, including human health, livestock, and the environment, while several interventions have been implemented to tackle the issue (Table 6). Indonesia has national guidelines on empirical antimicrobial therapy and has established a process of hospital accreditation, which includes the requirement for a hospital-based AMR control committee. The country has also banned over-the-counter sales of antimicrobials (i.e., without prescription) and the use of antibiotics for growth promotion in animal agriculture, including any use of the antibiotic colistin in livestock.

Despite these guidelines and regulations, multiple reviews have identified practices that continue to contribute to the misuse and overuse of antimicrobials. The drivers of such inappropriate antibiotic dispensing are complex and interwoven, ranging from a lack of basic knowledge about antibiotics and AMR, to the desire for financial gain (e.g., incentives are offered to maximize drug sales and animal production), to regulatory/enforcement circumstances across a geographically diverse country. The research collaboration known as PINTAR (Protecting Indonesia

38 Indonesia AMR National Action Plan (RENCANA AKSI NASIONAL PENGENDALIAN RESISTENSI ANTIMIKROBA TAHUN 2020-2024) (accessed January 3, 2022), https://cdn.who.int/media/docs/default-source/searo/indonesia/20221115_nap-on-amr.pdf?sfvrsn=20f27da3_1&download=true.

39 See the Global Database for the Tripartite Antimicrobial Resistance (AMR) Country Self-Assessment Survey (TrACSS) (accessed January 3, 2022), http://amrcountryprogress.org/.

Case Study 1
Indonesia

from the Threat of Antibiotic Resistance) has highlighted issues at community pharmacies, which dispense antibiotics without any input from trained physicians or pharmacists (Ferdiana et al. 2021; Karuniawati et al. 2020; Limato et al. 2021). The project is working to address behavior change and to incorporate best practices from the handling of the COVID-19 pandemic into the design of interventions. Antibiotics intended for use in livestock can also be purchased at pharmacies or feed shops without prescription, and they frequently are inappropriately used (without input from trained veterinary practitioners). As a result, high levels of resistance have been found in several pathogens, such as *E. coli* and *K. pneumonia*, both from human patients and animals or animal products (Hedman, Vasco, and Zhang 2020; Sivaraman and Parady 2018; Karuniawati et al. 2021).

The Joint Programming Initiative on Antimicrobial Resistance, or JPIAMR, is an international collaboration helping Indonesia to curb AMR. Through its COINCIDE project, JPIAMR is working to determine what will result from the ban on colistin use in animals; the intent is to help governments and clinicians safeguard colistin use for when it is needed. More investments are needed to allow for routine surveillance of pathogens and resistant genes in the environment, particularly in wastewater from hospitals, animal and food production facilities, and municipalities. To strengthen the capacity to monitor the effects of environmental pollutants on human health, and to develop water treatment plants that are fit for the context, innovative solutions are necessary. Research projects will inform ongoing activities in Indonesia to assess the AMR burden and continue development of surveillance capacity.

To address AMR, appropriate policies must be implemented, and a system must be built that can financially support those policies and allow for systematic surveillance of resistant infections' burden (Table 6). Like many low- and middle-income countries (LMICs), Indonesia still has limited information on antimicrobial use (AMU) and rates of resistant infections. Increasing AMR and AMU surveillance capabilities through a systemic collection of data will inform the knowledge base about AMR and drive appropriate AMU among prescribers and those who dispense or administer antimicrobial drugs.

Table 6. Addressing AMR across Sectors: Challenges and Existing Interventions

Antibiotic use in humans

CHALLENGES	EXISTING INTERVENTIONS
• Antibiotics are inappropriately dispensed at community pharmacies. • There is a high rate of empirical use of broad-spectrum antibiotics in hospitals. • According to the WHO AWaRe classification, watch antibiotics accounted for 67.4 percent of hospital prescriptions; access for 28.0 percent; and reserve for 2.4 percent.	• Over-the-counter sales of antimicrobials without prescription are banned. • National guidelines exist on empirical antimicrobial therapy. • Hospital accreditation requires a hospital-based AMR control committee. • Surveillance is routinely performed under the guidance of the Ministry of Health.

Case Study 1
Indonesia

Antibiotic use in animals

CHALLENGES	EXISTING INTERVENTIONS
• Antibiotics for livestock can be purchased at pharmacies and feed shops. • There is a lack of trained veterinary practitioners on farms. • Antibiotics are used prophylactically.	• Use of antibiotics for growth promotion and colistin use in livestock are banned. • Veterinarians or technical staff are required on farms to administer antibiotics. • Surveillance for AMR and AMU is performed under the guidance of the Ministry of Agriculture and Directorate General of Livestock and Animal Health Services (DGLAHS).

Antibiotics in the environment

CHALLENGES	EXISTING INTERVENTIONS
• Bacteria and antibiotic residues from food, animal production, and hospital wastewaters are found in the environment and in wild fauna.	• Wastewater treatment plants are present for municipal systems, hospitals, and abattoirs, though routine surveillance is not currently performed.

Policy implementation

CHALLENGES	EXISTING INTERVENTIONS
• Greater awareness and stewardship of antimicrobials are needed. • There is no national surveillance and data collection and reporting system. • The diverse geographic area made up of multiple islands is not coordinated.	• A PINTAR study aims at improving antibiotic sales practices. • The Fleming Fund strengthens surveillance and laboratory capacity with One Health focus. • The Tricycle Project aims at establishing cross-sectoral surveillance capacity. • The country is enrolled in GLASS and has established surveillance sites.

Source: World Bank.

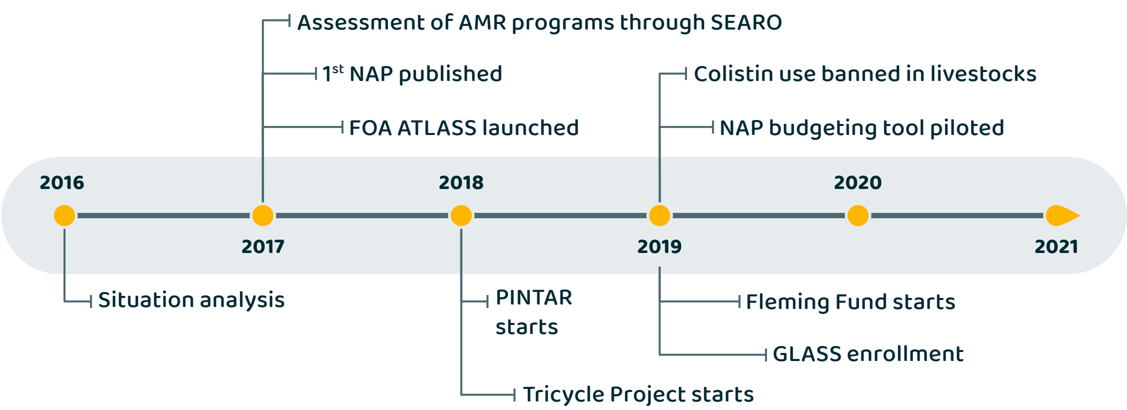
Note: AMU = antimicrobial use; AWaRe = access, watch, reserve; GLASS = Global Antimicrobial Resistance and UseSurveillance System; PINTAR = Protecting Indonesia from the Threat of Antimicrobial Resistance; WHO = World Health Organization.

Case Study 1
Indonesia

Actions taken to respond to AMR and enablers of progress

Indonesia has followed a stepwise approach to implementing AMR plans, with the long-term goal of developing an operational AMR containment program that has a sustainable funding mechanism and that incorporates functional monitoring and evaluation. The development of the initial Indonesia AMR NAP was supported by a situation analysis conducted in 2016, followed by the assessment of AMR programs by the WHO Southeast Asia Regional Office (SEARO) in 2017 (Kakkar, Sharma, and Vong 2017). In the same year, the FAO Assessment Tool for Laboratory and Antimicrobial Resistance (FAO_ATLASS) was launched in Indonesia, reinforcing the country's planned implementation of a national AMR surveillance system. That was followed by efforts to further build the surveillance capacity of the country with the start of the Tricycle Project, the enrollment into GLASS, and the receipt of funding from the Fleming Fund (Figure 2).

Figure 2. Timeline of Key Steps to Address AMR



Source: World Bank.

Note: FAO-ATLASS = FAO Assessment Tool for Laboratory and Antimicrobial Resistance; GLASS = Global Antimicrobial Resistance and Use Surveillance System; NAP = National Action Plan; SEARO = World Health Organization Southeast Asia Regional Office.

Indonesia's progress toward AMR containment has been enabled through three levels of commitment: community, national, and international. Table 7 shows the initiatives aimed at fulfilling AMU and AMR stewardship policy and program goals, along with how activities were implemented—that is, carried out within communities across the country, enabled through national policies, or enabled as part of larger international programs.

Case Study 1
Indonesia

Table 7. Actions Taken and the Enablers of Progress

ENABLER OF PROGRESS	INTERVENTION/ACTION	IMPLEMENTATION LEVEL: COMMUNITY	IMPLEMENTATION LEVEL: NATIONAL	IMPLEMENTATION LEVEL: INTERNATIONAL
National political commitment	Situational analysis report and Indonesia NAP are issued.		✓	
	Minister of Agriculture bans the use of antibiotics for growth promotion.		✓	
	Directorate General of Livestock and Animal Health Services (DGLAHS) bans colistin.		✓	
	National AMR Coordination Committee and AMR focal point are established.		✓	
	Surveillance sites are established; country is enrolled in GLASS.		✓	✓
	WHO Southeast Asia Regional Office tool to assess AMR programs is piloted.		✓	
International aid & support	FAO Assessment Tool for Laboratory and Antimicrobial Resistance (ATLASS) is launched.		✓	
	Fleming Fund strengthens surveillance capacity and aids NAP implementation.	✓	✓	
	WHO pilots the AMR financing and budgeting tool for NAP implementation.		✓	✓
	Multi-Partner Trust Fund makes investment to improve AMR awareness, optimize antimicrobial use, and strengthen surveillance.	✓	✓	
	WHO launches the Tricycle Project.	✓	✓	✓
Cross-country collaboration	PINTAR study is undertaken.	✓		
	Joint Programming Initiative on Antimicrobial Resistance (JPIAMR) is undertaken.	✓		

Source: World Bank.

Note: GLASS = Global Antimicrobial Resistance and Use Surveillance System; NAP = National Action Plan; PINTAR = Protecting Indonesia from the Threat of Antibiotic Resistance; WHO = World Health Organization.

Case Study 1
Indonesia

Strengthening surveillance capacity across all sectors: The Tricycle Project

In November 2018, the WHO Tricycle Project, using ESBL-producing E. coli as an AMR indicator, was piloted in Jakarta to promote and strengthen integrated surveillance across human, animal, and environmental sectors. The project brought together national political bodies (ministries), international organizations (WHO and the Fleming Fund), and regional centers (hospitals and research institutions) to collect data; this effort has not only provided AMR indicators of the spread of resistance nationally, but has also contributed to defining the burden of AMR globally (Table 8). The High-Level Inter-Ministerial Steering Committee (IMSC), formed by the Ministry of Health, Ministry of Agriculture, and Ministry of Environment and Forestry, coordinated the pilot, while the National AMR Coordination Committee (NARCC) implemented it nationally. Initial results were reported in 2021 and revealed a very high proportion of ESBL-producing E. coli in sample types across all sectors (Puspandari et al. 2021). The protocol in Indonesia also featured an added module, called EpiX (Puspandari et al. 2021), which expanded the epidemiological data collection and analysis to demonstrate the epidemiological interconnectedness between humans, animals, and the environment.

The first phase of implementation included training of the local researchers in data management and analysis and in use of the WHONET software. Trainings were held in 2017 in the Netherlands and Jakarta. Monitoring visits were also conducted at Rumah Sakit Persahabatan Hospitals, Health Center Jatinegara, slaughterhouses/markets, canals, the microbiology laboratory in the Indonesian National Institute of Health Research and Development (NIHRD), and the microbiology laboratory in the Ministry of Environment and Forestry. Findings and feedback from the visits revealed that the country had well-established surveillance systems for the human and animal sectors, but still had limited capacity to monitor AMR in the environment; this was also corroborated by the Joint External Evaluation (JEE) of the International Health Regulations (IHR) (GHS Index 2021).

While local researchers within the regional centers and the ministerial coordinating committees have showed a high level of commitment to implementing the Tricycle Project, there is still limited capacity to analyze epidemiological data. The AMR data currently collected originate primarily from the Java region. Although there were plans in place to establish laboratory networks across other regions, COVID-19 significantly slowed down the further rollout of the Tricycle Project and other programs. The Fleming Fund has been pivotal in supporting Indonesia, helping to build surveillance laboratory capacity for priority pathogens, train researchers and health care professionals in microbiology, and carry out sample collection and analysis. The Fleming Fund has also assisted with overall coordination across sectors, regional centers, and government bodies by supporting the implementation of coordinating mechanisms such as IMSC and NARCC.

Case Study 1
Indonesia

Table 8. Tricycle Pilot: Partners and Implementation Arrangements

IMPLEMENTING INSTITUTIONS	PARTNERS INVOLVED	MAIN RESPONSIBILITIES
International organizations	Fleming Fund	• Surveillance laboratory capacity building • Training of researchers and clinicians • Implementation support for national AMR committees
	US CDC	• Surveillance laboratory capacity building
	WHO	• Training of researchers and clinicians • Coordination of AMR activities
National ministries and research centers	High-Level Inter-Ministerial Steering Committee (IMSC) coordinated by • Ministry of Health • Ministry of Defense • Ministry of Agriculture • Ministry of Foreign Affairs	Overall governance for AMR strategy in Indonesia • Provides political commitment • Supports national containment efforts • Links to the international global health community
	National AMR Coordination Committee (NARCC) coordinated by • Different ministries • Governmental and nongovernmental agencies (e.g., civil society, media) • International agencies (WHO, FAO, WOAH, MPTF)	Implementation agency for the Indonesian NAP • Provides the platform and structure for program planning and implementation • Oversees technical working groups for each of the individual NAP strategic objectives
	Indonesian National Institute of Health Research and Development (NIHRD)	Coordination of national surveillance and sample analysis
	Balai Besar Laboratorium Kesehatan (BBLK) • Surabaya • Jakarta	National Reference Laboratories (human samples)
	Ministry of Environment and Forestry	Microbiology laboratories (animal and environmental samples)
Community centers	• Rumah Sakit Persahabatan Hospital • Health Center Jatinegara • Slaughterhouses/markets • Canals	Sample collection

Source: World Bank.

Note: FAO = Food and Agriculture Organization of the United Nations; MPTF = Multi-Donor Trust Fund; NAP = National Action Plan; WHO = World Health Organization; WOAH = World Organisation for Animal Health.

Case Study 1
Indonesia

Ongoing challenges and barriers to success

Economic circumstances and the COVID-19 pandemic continue to impact Indonesia's efforts to address AMR. A recent WHO costing and budgeting workshop noted that, until 2019, the budget allocations for AMR were low, and there was a lack of coordination (or ability to coordinate) across sectors (WHO 2021a). Additionally, the COVID-19 pandemic has brought unexpected challenges, slowing down the country's economic growth with the most significant drop since 1998 and pushing Indonesia's gross domestic product ranking from upper-middle income to lower-middle income in 2021.[40] The pandemic has also delayed the formal approval of the draft 2020–2024 Indonesia NAP on AMR that was completed in 2019 (WHO 2021a), in turn affecting progress on the Tricycle Project and its expansion to other regions.

Ensuring the long-term sustainability of the Indonesia NAP and the Tricycle Project will require financial plans that improve national laboratory networks. In 2021, a new Country Partnership Framework (2021–2025) was published, which prioritizes medium-term development plans and economic recovery from the COVID-19 pandemic (World Bank, IFC, and MIGA 2021). With funding from the Fleming Fund coming to an end in Indonesia, it is important to ensure that there are mechanisms in place for the long-term sustainability of the achievements made to date. Like other LMICs, Indonesia faces challenges with diagnostic laboratory readiness and even distribution of resources. As a result, laboratories, staff, equipment, and consumable capacities are concentrated within Java Island. With the bulk of the work still carried out by single research institutions or laboratories supported by independent grants, many other provinces are unable to meet demand for laboratory diagnosis. The geographical fragmentation of the country represents a real challenge, the experience with the scale-up of diagnostic laboratories during the COVID-19 pandemic has shown that equally distributed capacity and efficient cross-sector collaborations are needed. Additionally, systematic data collection, analysis, and sharing of surveillance data across the laboratory network are needed to draw a clear picture of the burden of AMR and to implement appropriate interventions based on need.

Takeaways for the benefit of other teams planning to implement similar or related interventions

A strong political drive, combined with international aid and willingness to collaborate internationally with key stakeholders in global health, has allowed Indonesia to exponentially grow its technical capacity to monitor the spread of resistant infections. As noted in the JEE of IHR Core Capacity, as of 2018 Indonesia already had sufficient laboratory capacity to conduct surveillance of relevant zoonotic diseases in the human sector (WHO 2018). Since 2019, the Fleming Fund has made significant investments in laboratory infrastructure enhancement, human resource strengthening, workforce reforms, surveillance system strengthening and data use, and rational use of antimicrobials. The Fleming Fund has enabled progress in implementation of NAP, the establishment of NARCC and the AMR focal point, and the rollout of the Tricycle Project. This work represents the first step toward the long-term sustainability of AMR containment interventions. Most recently, Indonesia received further investments from the Multi-Partner Trust Fund (MPTF), equal to US$1 million, to improve AMR awareness, optimize antimicrobial use, and further strengthen surveillance capacity across all sectors. The government of the Netherlands has also provided extra funds to build veterinary surveillance capacity as part of the expansion of the Tricycle Project.

40 See World Bank, "The World Bank in Indonesia," https://www.worldbank.org/en/country/indonesia.

Case Study 1
Indonesia

The establishment of funding partnerships that support local leaders in driving the AMR agenda, both within the community and in government, has been critical to the success seen in Indonesia. Such partnerships allow for a bottom-up approach that leverages existing structures and local capabilities alongside international expertise and technical training to advance in-country capacity. The key steps that Indonesia has taken to address AMR to date are presented below. These might prove useful as recommendations to other teams or countries working toward the implementation of AMR containment activities.

1. **Political action to ensure support for AMR. Indonesia has actively engaged with external stakeholders such as the Fleming Fund and the US CDC to strengthen its AMR operational capacity.** Most recently, the government has further formalized its interest in actively tackling global health challenges by signing a Memorandum of Understanding on health cooperation and antimicrobial resistance surveillance with the United Kingdom. Furthermore, it has formally established national AMR committees in charge of implementing and monitoring AMR action.

2. **Accountability of local actors and capacity building through active support of local research communities.** Local experts and Fleming Fellows have supported the coordination of AMR projects across the country in collaboration with ministries. In particular, training of local staff has ensured that knowledge and expertise are retained within the country, paving the way to self-sustainability. Additionally, collaborations with international research stakeholders have contributed to strengthening the local technical capacity to conduct surveillance and stewardship of antimicrobials.

3. **Translation of political will into resources, including funding through multisector resource mobilization.** Partnerships with the Fleming Fund, MPTF, and others have translated into tangible resources (financial and operational) aimed at strengthening AMR surveillance capacity and increasing AMR awareness and responsible use of antimicrobials. The implementation of the WHO budgeting tool, which is also underway, will further strengthen the prioritization and availability of financial resources for the implementation of AMR NAP activities in the country.

4. **Use of strategic information to drive input by performing country-level AMR situation analysis to understand progress and bottlenecks.** This step could include use of the WHO budgeting tool and participation in activities to implement NAP; conduct of a situation analysis and testing of others' tools to determine how AMR programs are faring and to identify challenges that are specific to the context and country; and participation in the WHO GLASS and Tricycle Project to expand national surveillance capacity across human, animal, and environmental sectors.

5. **Better policies through improved dissemination and uptake of global policies.** This step involves support for WHO in the dissemination and uptake of policies and guidelines through regular engagement and meetings. For instance, Indonesia has worked closely with WHO and other international stakeholders to develop and implement guidelines for the responsible use of antimicrobials in farming, in the community, and in hospitals.

Case Study 1
Indonesia

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Case Study 2
Tanzania

Tanzania:
Building community-led AMR surveillance capacity through mobile technology

Summary

This case study describes key findings from Tanzania's work to establish cross-border relationships and a sustainable technology infrastructure for community-based infection, outbreak, and antimicrobial resistance (AMR) surveillance. Over the past decade, partnerships between Tanzanian and international agencies have built training and software development programs that aim to empower community members in One Health infectious disease surveillance, while building relationships and promoting shared decision-making between community data reporters and national government officials. Tanzania's collaborative and technology-driven work culminated in 2018 with the launch of AfyaData, a mobile application that allows community members to collect, report, analyze, and receive feedback on AMR and infectious disease data.

The use of AfyaData to respond to infectious disease outbreaks garnered investment from Tanzania's national Ministry of Health (MoH), and the app was deployed to measure drug resistance in community-acquired urinary tract infections (UTIs), which country officials have identified as a significant driver of inappropriate antibiotic prescribing that is possibly increasing drug resistance. A pilot study made possible by close collaboration between the community, the national government, and international agencies indicated that multidrug-resistant (MDR) strains of bacteria were a prevalent cause of UTI in the community. Findings laid the groundwork for guidelines on community UTI prescribing (currently in development) and affirmed the importance of technology-based, community-focused AMR surveillance as part of a national and cross-border infectious disease strategy.

The context and specific challenges being addressed

More is known about antibiotic use than about AMR in Tanzania. Data are scarce on the burden of AMR in Tanzania. More is known about the prevalence of inappropriate antimicrobial prescribing or purchasing, which is a known contributor to increases in drug resistance. Investigative studies have found that antibiotics to treat fever—most commonly ampicillin, tetracyclines, and ciprofloxacin—are frequently sold without a prescription and in suboptimal doses if the purchaser is unable to afford the entire dose (Makoye 2021; Mbwasi et al. 2020).

Tanzania is focused on implementing National Action Plan strategies for AMR surveillance and measurement. Tanzania participates in the WHO Global Antimicrobial Resistance and Use Surveillance System. As of 2022, the country reports AMR data on bloodstream infections and UTIs to GLASS (WHO 2022). Tanzania's MoH adopted a National Action Plan on AMR in 2017, establishing priorities for the control of AMR and antimicrobial use in human and veterinary health through 2022 (MoH 2017). NAP implementation is overseen by an AMR focal point—the Pharmaceutical Services Unit, which sits within MoH. The NAP identifies improvement of surveillance systems as one of five urgent goals, and calls the lack of health care resources and programs to improve public awareness and education a key weakness that may inhibit achievement of the NAP's objectives (Frumence et al. 2021).

Case Study 2
Tanzania

Governance and committee structures outlined in the NAP have the capability to promote AMR surveillance at the national level, but communities' capacity for testing for AMR and knowledge about AMR vary significantly. Tanzania's Multi-Sectoral Coordinating Committee is co-chaired by the chief medical officer and the WHO representative to Tanzania and comprises a diverse membership drawn from national human health, agriculture, horticulture, food, and environment agencies, as well as from the Africa Centres for Disease Control and Prevention and international health and development agencies. The committee supervises all surveillance implementation activities, although the country's AMR surveillance framework primarily focuses on antimicrobial use in hospital and agricultural settings. As of 2021, nine laboratories across the country were equipped to perform antimicrobial susceptibility testing, and 63 sites—45 of them larger facilities that provide acute and outpatient care—contributed data to the national surveillance system. Though promotion of various NAP activities has been underway at the national government level for years, capacity for carrying out AMR work at the local level varies by region and setting. A 2020 survey found that most Tanzanian clinicians were not aware of the NAP; only 23 percent had software to collect and store data on AMR, and 15 percent had access to policies and guidelines for appropriate antibiotic treatment (Sangeda et al. 2020).

A lack of AMR surveillance in the community and misuse or lack of access to appropriate antibiotics have raised questions about how common infections, such as UTIs, contribute to AMR burden within the community. UTI is one of the most common bacterial infections globally and is usually diagnosed and treated with antibiotics based on the presence of symptoms (fever, urinary pain) in primary care settings. If medical care is not available, it may be treated by waiting for symptoms to resolve, antibiotic self-prescription, or traditional healing practices. Drug-resistant UTIs in the community can be a risk factor for bloodstream infection and the development of MDR infections and hard-to-treat infections (Madut et al. 2020), and Tanzania has recently documented an increased spread of MDR pathogens outside of hospitals (Moremi 2022). In Tanzania, UTI is the second most common reason for seeking health care among people ages five and older and the most common reason among children younger than five. A gap analysis conducted by the Southern African Centre for Infectious Disease Surveillance (SACIDS) across four East African countries, including Tanzania, identified numerous issues contributing to antibiotic overprescription for UTIs and the risk of rising AMR, including a shortage of trained prescribers and laboratory staff, the lack of clear empirical prescribing guidelines for UTI, the fact that existing surveillance structures do not collect community AMR or UTI data, and the lack of infrastructure and guidelines to carry out AMR susceptibility testing on community urine samples (Silago et al. 2022).

Actions taken to respond to AMR

Local health training formed the basis of Tanzania's community AMR surveillance plans. In 2010, with funding from the Rockefeller Foundation and the goal of moving from paper-based to technology-guided infectious disease surveillance, SACIDS began training the staff of primary health care facilities across Tanzania on infectious disease data collection and analysis with the open source EpiCollect and Open Data Kit apps. Funding from the Canadian International Development Research Centre replaced Rockefeller Foundation support in 2013 and sustained the training program through 2017 (Karimuribo et al. 2017), after which numerous international foundations funded specific training and technology development projects.

Case Study 2 Tanzania

An EpiHack event brought the importance of accessible technology to the forefront of community surveillance efforts.[41] The EpiHack in AMR surveillance generated significant awareness of the importance of contributions from primary health care physicians, pharmacists, laboratory professionals, and health care administrators to national infection surveillance. In 2014, funding from the Skoll Global Threats Fund allowed SACIDS to host EpiHack Tanzania, an event that brought together 66 software developers and health professionals from Africa, Asia, and North and South America. The EpiHack fostered discussions between developers and health experts on pressing infectious disease challenges that could be simplified by a technology-based intervention (Karimuribo et al. 2017).

The Enhancing Community-Based Disease Outbreak Detection and Response in East and Southern Africa (DODRES) project provided infrastructure, training, and technology that enabled community-led surveillance. The EpiHack was followed in 2015 by a training session to identify ideas and practices aligned with the Global Health Security agenda that could be implemented by SACIDS's community-centered One Health Security Initiative. SACIDS again hosted the workshop, which was funded by the Skoll Global Threats Fund and the Bill and Melinda Gates Foundation and which included members of the Mekong Basin Disease Surveillance Foundation. The Mekong Basin group was instrumental in guiding discussions around using mobile technology for cross-border partnerships and One Health surveillance near waterways. The major outcome of the workshop was the formation of the DODRES project, which was ongoing as of 2022.

Community-led AMR surveillance initiatives worked across East African borders from the outset. DODRES sought to develop infectious disease surveillance tools that could be used within communities, shared information easily with the national Integrated Disease Surveillance and Response System, and strengthened cross-border knowledge and partnerships in East Africa. The formation of DODRES, funded by Ending Pandemics and the Skoll Global Threats Fund, involved close collaboration between SACIDS, the Tanzanian National Institute for Medical Research, the Kenyan Medical Research Institute, Morogoro Municipal and Ngorongoro District Councils in Tanzania, the Narok County government in Kenya, and officials from ministries for health and livestock development in both Tanzania and Kenya.

Collaborations and technological groundwork laid the basis for the creation of three app-based AMR surveillance tools. The Techno-Health Innovative Laboratory, established in 2015 at Morogoro Regional Hospital in Tanzania, provided a base for a DODRES design team made up of information and communication technology experts and programmers. The team received mentorship and training from the US-based organization Innovative Support to Emergencies, Diseases, and Disasters. The laboratory chose to use the theory-of-change framework to evaluate its efforts to develop technologic approaches that could be used in and by communities, and in 2016 it issued the first TechnoHealth Surveillance newsletter, which connected partners and the general public to the work being led by DODRES. One of the major activities initiated by DODRES was the creation of three app-based tools; after pilot-testing the prototypes in the laboratory's urban district and at a cross-border site in Tanzania and Kenya, the tools were packaged together in 2018 as the AfyaData infectious disease surveillance mobile application (Karimuribo et al. 2017).

Table 9 highlights the actions taken to develop the AfyaData app and improve awareness of AMR and infectious disease surveillance in Tanzania since 2013, along with the different actors involved in each project.

41 An EpiHack, or epidemiology hackathon, is a gathering of health professionals and software developers intended to develop low-cost and open source technology for public health projects. For more information, see the EpiHack website at https://epihack.org/.

Case Study 2
Tanzania

Table 9. Actions Taken to Respond to AMR in Tanzania: 2013–2018

IMPLEMENTING INSTITUTIONS	PARTNERS INVOLVED	MAIN RESPONSIBILITIES
International organizations	• Rockefeller Foundation • Canadian International Development Research Centre • Skoll Global Threats Fund • Bill and Melinda Gates Foundation • Ending Pandemics	Providing financial support to the EpiHack, training programs, launch of DODRES, and AfyaData development
	• Mekong Basin Disease Surveillance Foundation • Government officials from Kenya's Narok County • Officials from Kenya's Ministry of Health and Ministry of Agriculture, Livestock, Fisheries, and Cooperatives • Kenya Medical Research Institute	Providing technical assistance and advice on cross-border and One Health infectious disease surveillance
	• Innovative Support to Emergencies, Diseases, and Disasters	Providing training and mentorship on the use of information technology for AMR surveillance
National ministries and research centers	• SACIDS	Providing training to community health workers on app-based infectious disease surveillance
	• SACIDS • Ending Pandemics	Forming a community-based infectious disease outbreak surveillance program based on identified priorities
	• SACIDS • Ending Pandemics • Tanzanian National Institute for Medical Research	Establishing a resource hub to meld technology, design, and infectious disease surveillance priorities and communication
	• SACIDS • Ending Pandemics • Tanzanian National Institute for Medical Research	Creating the AfyaData app for infectious disease and AMR surveillance
	• Morogoro Municipal Council • Ngorongoro District Council • Morogoro Regional Hospital	Guiding technology-based surveillance interventions through advocacy for infectious disease priorities
Community groups and local organizations	• Community health workers • Members of the public	Attending training and ongoing communication efforts for infectious disease surveillance projects

Source: World Bank.

Note: DODRES = Enhancing Community-Based Disease Outbreak Detection and Response in East and Southern Africa; SACIDS = Southern African Centre for Infectious Disease Surveillance.

Case Study 2 **Tanzania**

Implementation arrangements

The AfyaData mobile app enables data collection, analysis, feedback, and outbreak prediction.[42] SACIDS launched the AfyaData mobile app in 2018, along with a training initiative to ensure that AfyaData was usable in communities and across human health and veterinary settings in Tanzania. The AfyaData package comprises (i) an app for data collection; (ii) a web-based server to map, analyze, and provide feedback on surveillance data; and (iii) a disease-prediction and decision-making repository developed by the DODRES team and the Tanzanian National Institute for Medical Research through extensive consultation with health experts.

Communication between community reporters and national government officials enabled the national government to stay up to date with AMR and infectious disease issues. Community users of the AfyaData app who were trained to report AMR data and potential outbreaks, along with MoH officials, could receive feedback on submitted data through the AfyaData server, and often used WhatsApp to share best practices and challenges of the One Health approach (Karimuribo et al. 2017). Table 10 summarizes the activities that contributed to the launch and use of AfyaData and the app's implementation at the MoH level, at the nonprofit and academic level in Tanzania (e.g., SACIDS), across country borders, in collaboration with international nonprofits (e.g., Ending Pandemics), and in community settings with trained primary health care providers and members of the general public.

Table 10. AfyaData Implementation Activities across Tanzania and Neighboring Countries

	IMPLEMENTATION LEVEL				
IMPLEMENTATION ACTIVITY	NATIONAL (Tanzania MoH)	NATIONAL (nonprofit [e.g., SACIDS])	COMMUNITY AND PRIMARY HEALTH CARE	INTERNATIONAL (government)	INTERNATIONAL (nonprofit)
Launch of AfyaData mobile app's three interactive modules					
AfyaData module 1: Android-based client app for offline data collection		✓			
AfyaData module 2: Web-based app/server that maps the geographic distribution of infectious disease reports and handles the life cycle of surveillance data		✓			
AfyaData module 3: One Health Knowledge Repository that serves as an infectious disease and outbreak-prediction and decision-making system	✓	✓			
Initial AfyaData training and implementation in Tanzania					
Training of government officials and community reporters to use AfyaData for cholera surveillance across 10 Tanzanian districts	✓	✓	✓		

42 For more information, see the SACIDS AfyaData website at http://afyadata.sacids.org/.

Case Study 2 **Tanzania**

IMPLEMENTATION ACTIVITY	IMPLEMENTATION LEVEL: NATIONAL (Tanzania MoH)	NATIONAL (nonprofit [e.g., SACIDS])	COMMUNITY AND PRIMARY HEALTH CARE	INTERNATIONAL (government)	INTERNATIONAL (nonprofit)
Use of WhatsApp to conduct training, enable feedback on submitted data to community reporters, and share best practice and outbreak warnings	✓	✓	✓		
Ebola outbreak response					
Deployment of AfyaData to the Democratic Republic of Congo to enable community-focused surveillance during the 2018–2020 Kivu Ebola outbreak	✓	✓		✓	
Training of Democratic Republic of Congo health ministry officials and community reporters on potential uses of AfyaData for Ebola surveillance	✓	✓	✓	✓	
Protocol for surveillance of MDR community-acquired UTI					
Gap analysis of needs and opportunities for the development of shared surveillance protocols across Malawi, Tanzania, Uganda, and Zambia		✓			✓
Development of a study protocol to understand the magnitude and drivers of MDR community-acquired UTI and formulate an AMR control strategy in the community, while gathering information to strengthen the NAP	✓	✓		✓	✓
Use of AfyaData to collect and analyze clinical and demographic information on patients presenting with UTI symptoms in primary care clinics in Mwanza and Dar es Salaam		✓	✓		✓
Susceptibility testing through partnerships with national laboratories and via the WHONET microbiology laboratory database software	✓	✓			
Identification of next steps, including translation of the protocol and study methods to other countries and use of the data to inform the development of UTI prescribing guidelines and policy	✓	✓	✓		✓

Source: World Bank.

Note: MDR = multidrug-resistant; NAP = National Action Plan; SACIDS = Southern African Centre for Infectious Disease Surveillance; UTI = urinary tract infection.

Case Study 2 **Tanzania**

The next step in using AfyaData for AMR surveillance was to draw on the collected data to inform antibiotic guidelines. Community reporters and health officials needed guidance in integrating community surveillance with antimicrobial stewardship while also using data to inform national AMR policies and evaluation of the NAP. A UK Fleming Fund grant to Ending Pandemics supported SACIDS in developing and implementing a community-based AMR surveillance protocol on UTI. The protocol was built to understand the dynamics of MDR community-acquired UTI and incorporated (i) case definitions for UTI categories of infection and demographics assembled across several published studies, (ii) national standard operating procedures for urine sample collection, and (iii) Clinical & Laboratory Standards Institute (CLSI) breakpoints and the WHONET microbiology laboratory database software for susceptibility testing and reporting (Silago et al. 2022).

The identification of a high prevalence of MDR community-acquired UTI led a pilot study to become a case study for guideline and policy implementation. A study of patients seen for UTI symptoms in two Tanzanian primary care clinics found that more than half of 143 *Escherichia coli* isolates were resistant to more than three classes of antibiotics (Silago et al. 2022). Despite the limited nature of a pilot study, the finding of pervasive MDR pathogens prompted researchers to develop a project to create empirical antibiotic prescribing guidelines and a national-level community surveillance program.

Enablers of progress

Several enablers of progress allowed AfyaData to grow from an idea about community-led surveillance into a tool that provides information on drug-resistant UTI in the community—information that formed the basis for the development of empirical antibiotic prescribing guidelines: (i) the value it demonstrated during a cholera outbreak; (ii) constant communication between the community and government leaders; and (iii) a commitment by stakeholders to use data to build needed prescribing guidelines and fight AMR. Each of these is discussed below.

A cholera outbreak demonstrated the value of community-led surveillance to national MoH officials. One of the most important factors in connecting community-focused surveillance work to involvement and investment from the MoH was a 2015–2016 outbreak of cholera. Government officials attributed the long duration of the epidemic to the fact that community-level data were not available to the paper-based national surveillance system at the outset. In 2016, as cholera cases continued to mount, a Tanzanian government official recommended that the MoH consult with SACIDS to deploy an early form of AfyaData in five Tanzanian districts; the purpose was both to conduct epidemic surveillance and build a structure for technology-based community reporting into the national infectious disease surveillance system (Ending Pandemics 2017).

Ongoing app-based conversations were essential to providing the community with feedback on submitted data and helping government officials use data to meet AMR goals. The One Health Knowledge Repository and the problem-solving community formed on WhatsApp gave community reporters access to valuable real-time feedback from officials about the meaning or implications of data they submitted. Because of this link with the national government and health experts, community reporters had access to knowledge that could lead to protective action against a possible outbreak or to identification of drug-resistant bacteria. Health Ministry officials, in turn, were able to integrate community-level data on AMR into the national surveillance system (Karimuribo et al. 2017; Ending Pandemics 2017).

Case Study 2 **Tanzania**

Stakeholder commitment to app development and training was integral to informing clinical guidelines. Interviews with national AMR focal point officials helped to reveal the extent of inappropriate empirical prescribing for UTIs. In addition, Tanzania's National Public Health Laboratory (NPHL) ensured the quality of data submitted via AfyaData by community reporters throughout the UTI study. Data were sent to the NPHL via the WHONET software, a process that offered an opportunity to successfully test how well the national urine collection protocol conformed to global susceptibility reporting structures. Ongoing support for the project and feedback to reporters from the National Institute for Medical Research and MoH within the AfyaData app was invaluable and was built over years through an understanding that community surveillance could help achieve local prescribing improvements and national AMR goals at the same time.

Challenges and barriers to success

Many of the challenges and barriers to success involved a lack of information and infrastructure for community data collection. Addressing a lack of information meant not only collecting data but also demonstrating that community data could change existing policies and further national AMR goals. Growing investment from national officials was integral to ensuring that community-led AMR surveillance became a key piece of Tanzania's health infrastructure. Table 11 highlights several barriers to the success of a community-led AMR surveillance approach, along with the factors contributing to these challenges and potential solutions or interventions.

Table 11. Barriers and Solutions to Community-Led AMR Surveillance in Tanzania

CHALLENGES AND BARRIERS TO SUCCESS	CONTEXT FOR THE CHALLENGES	INTERVENTIONS OR POTENTIAL SOLUTIONS
Lack of **information** on the usefulness or design of community-based data tools	• AMR surveillance data come primarily from hospitals, where data can more easily inform changes in protocols. • Published studies on community AMR in Tanzania are lacking, and the few that exist focus on specific populations, such as pregnant or immunocompromised people.	• AfyaData demonstrated that community data used to alert health officials to potential outbreaks, such as cholera, can be used to track AMR. • A common surveillance protocol for UTI can support the translation of community surveillance into evidence-informed guidelines.
Lack of **infrastructure** for community-based infectious disease data collection	• The national surveillance system focuses on collecting hospital-based data. • Many communities do not have access to laboratory testing, making it difficult to understand the burden of AMR.	• AfyaData built a structure for collecting, analyzing, and responding to community-level data. • Partnerships with the national laboratory and the use of WHONET software ensured that community isolates could be tested for resistance.

Limited **applicability** of global guideline to local circumstances	• WHO guidelines do not recommend screening for extended-spectrum beta-lactamases (ESBLs) in community-acquired UTI caused by Enterobacterales.	• Community data can guide physicians when susceptibility and ESBL testing are needed, especially when laboratory testing is unavailable.

Source: World Bank.

Note: UTI = urinary tract infection; WHO = World Health Organization.

Takeaways for the benefit of One Health teams planning to implement similar or related interventions

Tanzania's experience of developing a tool and a network for community-based surveillance of infections, outbreaks, and AMR could help other teams planning a similar community-based project. Key elements of Tanzania's success include the following:

1. **Iterative, step-by-step process.** Rather than focus on the long-term sustainability of the project at the outset, SACIDS took an iterative approach to the development of AfyaData, seeking out diverse funding sources that would enable one clear step of the project. This approach allowed SACIDS the freedom to build a tool and foster a community that arose from relevant infectious disease surveillance needs; the approach also empowered shared leadership for different aspects of the project, and allowed the tools to be tested in real-life surveillance situations.

2. **Relevance to clinical guidelines and policy.** AfyaData's use for community-led surveillance provided a digital platform for timely data collection and rapid understanding of Tanzanian UTI pathogens and antibiograms, which facilitated the creation of rational empirical therapy guidelines still in development.

3. **Diverse networks.** Learning from South and Southeast Asian projects about infectious disease surveillance in river basins and across national borders via the Mekong Basin Disease Surveillance Foundation helped to build a more sustainable project, one that concentrated on human health but incorporated a One Health focus and methodology.

4. **Collaboration between community and government.** Relationships built on knowledge exchange and feedback between health officials and community members broadened the national surveillance focus to include disease and drug resistance occurring outside of hospitals.

5. **Training and mentorship.** Training programs on infectious disease and AMR surveillance and reporting promoted a participatory relationship between community members, government officials, clinicians, and laboratory staff, creating the potential for harmonized work during a public health crisis and community involvement in developing in-progress prescribing guidelines.

Case Study 2
Tanzania

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Case Study 2
Nigeria

Nigeria:
Strengthening laboratory capacity for antimicrobial resistance

Summary

Limitations in laboratory capacity hinder the prompt identification of pathogens and the antibiotic susceptibility testing needed to mitigate the spread of antimicrobial-resistant pathogens in Nigeria through optimal surveillance. The Nigerian National Action Plan highlights the existence of too few quality-assured microbiology laboratories as a major challenge in the fight against AMR in the country. A lack of trained personnel with the requisite skills to man these laboratories, along with difficulties in procuring supplies needed to ensure their smooth operation, poses another challenge. Strengthening laboratory systems in Nigeria will be important for generating the high-quality data needed to inform actions and policies that curtail the spread of AMR.

Together with international partners, Nigeria is currently implementing interventions as part of a multiphase AMR program aimed at strengthening diagnostic stewardship in major health care facilities. Strengthened laboratory facilities, efficient pre-analytic clinical processes, and the timely use of quality-assured laboratory data play a crucial role in supporting patient care, AMR surveillance, and diagnostic stewardship. This case study describes two initiatives that aim to build resilient health systems and a trained workforce in order to better address AMR. The two partnerships highlighted in this case study are the Diagnostic Stewardship subproject of the Capacity Development for Preparedness and Response for Infectious Diseases (NiCaDe) project and the Regional Disease Surveillance Systems Enhancement (REDISSE) project. The case study outlines implementation arrangements, enablers of progress, challenges and barriers to success, and takeaways to support the implementation of similar interventions in other countries.

The context and specific challenges being addressed

The paucity of high-quality AMR data and absence of a robust national AMR surveillance system are challenges for Nigeria. Nigeria's NAP highlights too few quality-assured microbiology laboratories as a challenge. To better manage infectious diseases and the associated AMR, the generation of high-quality microbiological and clinical data is essential. Nigeria has made some progress in strengthening health systems and infrastructure but still faces significant gaps in equipment availability, laboratory reagents, and trained personnel needed to perform standard blood cultures in secondary health care facilities (Federal Ministries of Agriculture, Environment, and Health 2017a). Some of the challenges facing laboratories in Nigeria are also linked to broader country-specific infrastructural challenges, such as poor power supply. In addition, limited data capture systems, local manufacturing of equipment, and the use of low-quality or substandard reagents may also affect laboratory results. These challenges have created gaps that increase the use of broad-spectrum antibiotics, and that could, in turn, lead to the spread of more resistant pathogens.

The national surveillance program in Nigeria has not effectively captured information on AMR. AMR diagnostics that currently support national surveillance are primarily undertaken by a few teaching hospitals and private laboratories in universities in the context of multiple ongoing research projects with international academic and research institutions. The National Reference Laboratory (NRL) currently supports only limited AMR activities because of insufficient materials, infrastructure, and clinical bacteriology expertise for quality assurance. Without a robust and representative national AMR surveillance program, generating reliable data to inform treatment guidelines or policy is difficult.

Actions taken to respond to AMR and implementation arrangements

Nigeria has made substantial progress in response to AMR. It has AMR-specific national action plans and an ongoing collaboration with international partners to improve the AMR surveillance system and strengthen laboratory capacity within the country. The Implementation activities and actions taken to respond to AMR across Nigeria are summarized in Table 12. The Nigeria Centre for Disease Control (NCDC) coordinates prevention, response, and control activities across the human, animal, and environmental sectors in line with the One Health approach articulated in the NAP for AMR. As the central coordinating body and AMR focal point, the NCDC led Nigeria's situation analysis in 2016, the development of Nigeria's 2017–2022 NAP (Federal Ministries of Agriculture, Environment, and Health 2017b; NCDC 2018), and the One Health Strategic Plan 2019–2023 (Federal Republic of Nigeria 2019), where AMR was considered a major focus for One Health actions. These documents were developed in collaboration with key stakeholders from the Federal Ministry of Agriculture and Rural Development (FMARD), the Federal Ministry of Health (FMOH), and the Federal Ministry of Environment (FMOE), with support from Global Antibiotic Resistance Partnership (GARP) Nigeria.

With the formation of the national Antimicrobial Resistance Coordination Committee (AMRCC) to shape, oversee, and monitor AMR-related activities across sectors for systematic and comprehensive implementation, the governance structure for implementing the initiatives above was intended to reflect multidisciplinary and sectoral integration. The operational aspect of the national AMR activities in Nigeria is overseen by the national AMR Technical Working Group (ATWG). This working group has representation from the government ministries, departments, and agencies across One Health sectors, including academia and the private sector. This structure facilitates intersectoral coordination at the national level and serves as a governance template that can be replicated at the lower levels and in line with Nigeria's tiered political and health systems. The NCDC is supported by a range of partnerships with public health institutes and nongovernmental organizations.

The AMR coordinating center at the NCDC has also built a network with sentinel sites (designated AMR centers selected from across the country) and secondary health care facilities for AMR surveillance. Through existing government funds and support from development partners, the NCDC has overseen the establishment of the NRL to support pathogen surveillance and has made substantial progress in strengthening public health infrastructure in Nigeria. In addition, AMR testing has been incorporated into other existing systems, such as the laboratories of the National Institute of Pharmaceutical Research and Development (NIPRID), the National Veterinary Research Institute (NVRI), and other regional laboratories supported with funding from the Fleming Fund and other partners.[43] However, the NRL currently does not support many AMR activities due to gaps in the availability of materials for quality assurance, infrastructure, and clinical bacteriology expertise. The main activities in bacteriology have been limited to the surveillance of cerebrospinal meningitis and cholera.

43 For information on the Nigeria grant, see Fleming Fund, "Nigeria Country Grant," https://www.flemingfund.org/grants/nigeria-country-grant/.

Case Study 2
Nigeria

AMR diagnostics are primarily undertaken by teaching hospitals and private laboratories in universities in the context of multiple ongoing research projects with international academic and research institutions. In addition, resistant TB surveillance programs are in place within the country. The Global Fund currently supports an existing resistant TB detection program in Nigeria public hospitals.

The national AMR surveillance system was established in 2017 with 19 laboratories (11 human health and 8 animal health laboratories) to strengthen diagnostic capabilities and epidemiological data collection. The Fleming Fund has been instrumental in establishing and maintaining these laboratories. There is also improved coordination of AMR activities in the country and synergy between the NCDC and relevant ministries and agencies. NVRI was recently designated as the NRL for animal health and oversees the surveillance of AMR in food systems, livestock, poultry, aquaculture, and other related sectors. This One Health and interdisciplinary approach is critical for ensuring functional infection prevention and control (IPC) systems within farms and health facilities. Capacity was scaled up in response to the COVID-19 pandemic, especially in molecular surveillance of viral diseases across sectors. Cumulatively, there is increased capacity for clinical, laboratory, and research staff, and the country is slowly taking greater ownership of the AMR response.

The World Bank REDISSE project (World Bank 2020) has helped to build capacity for zoonotic disease surveillance, laboratories, outbreak preparedness, human resources, and institutional capacity in Nigeria (Box 10). The project fosters One Health competencies that are AMR-sensitive and helps to address the public health challenges that might arise from the interaction between humans, animals, and the environment, including those associated with AMR. The World Bank's US$200 million intervention in the COVID-19 pandemic positioned Nigeria and other African countries participating in the REDISSE project to mount an early and effective response to COVID-19.

Box 10. REDISSE Project in Nigeria

REDISSE Project in Nigeria

The World Bank launched the REDISSE project in 2016 to respond to the challenge of infectious diseases and help protect countries from current epidemic threats like Ebola and from any future epidemics. The project became effective in Nigeria on February 13, 2018, and is jointly implemented by the NCDC, FMOH, and FMARD. As the COVID-19 pandemic escalated, the REDISSE project provided more than US$200 million for the response in 13 countries in West and Central Africa.

By working closely with the German Robert Koch Institute (RKI), the NCDC is improving diagnostic and antibiotic stewardship programs in many health care facilities in Nigeria. So far, IPC training guidelines have been developed with support from RKI and the US Centers for Disease Control and Prevention. The RKI diagnostic stewardship project (GHPP 2021) serves as a proof-of-principle diagnostic stewardship intervention; it provides technical and material support to improve the generation of quality-assured microbiologic data, which are needed to inform clinical antimicrobial therapy in preselected model secondary hospitals and as part of AMR surveillance nationally. The program promotes patient-centered interdisciplinary communication strategies through the NiCaDe project. Some of the resources and capacity provided also supported diagnostics of SARS-Cov-2 as part of the national response to the COVID-19 pandemic.

Case Study 2
Nigeria

The efforts of various professional bodies and agencies have helped to increase the general public's awareness of AMR. Professional bodies—such as the Veterinary Council of Nigeria (VCN), the Medical Laboratory Science Council of Nigeria (MLSCN), and the Nigeria Medical and Dental Association—integrate AMR education into their continuing education programs and conferences to raise awareness directly among professionals and indirectly among the general public. Agencies, including the National Agency for Food and Drug Administration and Control (NAFDAC) and National Primary Health Care Development Agency (NPHCDA), also carry out education and awareness activities on hand hygiene and WASH (water, sanitation, and hygiene) among health care workers and within communities and schools. These campaigns are aimed as contributory but foundational strategies to reduce the burden and spread of diseases and, thus, the need for antimicrobials.

Establishment of the national One Health Antimicrobial Resistance/Antimicrobial Use Community of Practice (COP) by the government of Nigeria, with support from development partners, has enhanced and continues to ensure the exchange of ideas to support and improve AMR activities and stewardship in the country through a One Health approach. For example, as part of World Antimicrobial Awareness Week 2021, a National Awareness Walk was held in the nation's capital to create public awareness of responsible antibiotic use.

Nigeria has been enrolled in the WHO GLASS surveillance network for AMR since April 2017. The collection, analysis, and sharing of AMR data by countries are increasingly standardized through GLASS. As a result, Nigeria and other participating countries can now better monitor and compare resistance patterns and use the data to inform policy. Veterinary clinicians are also encouraged to follow the WOAH guidelines on antimicrobial agents for use in animals.

The establishment of the Field Epidemiology and Laboratory Training Program (FELTP) in Nigeria with the support of the US CDC is also important for outbreak preparedness and response.[44] Complementary but specific to the AMR response is the Fleming Fund's public health leadership program that trains fellows from across the One Health spectrum to support AMR programs and surveillance activities. The fellows from Nigeria constitute a trained workforce team with enhanced capacity, increasingly leading the implementation and taking national ownership of national strategies.

The WHO Tricycle surveillance project is a more recent One Health intervention strengthening surveillance of ESBL *Escherichia coli* in animals, humans, and the environment (WHO 2021). The project's implementation in Nigeria and other countries uses a WHO-approved protocol that compares the local and regional evidence base to advance strategies for combatting AMR.

44 TEPHINET (Training Programs in Epidemiology and Public Health Interventions Network), "Nigeria Field Epidemiology and Laboratory Training Program," https://www.tephinet.org/training-programs/nigeria-field-epidemiology-and-laboratory-training-program.

Case Study 2
Nigeria

Table 12. Implementation Activities and Actions Taken to Respond to AMR across Nigeria

IMPLEMENTING INSTITUTIONS	ACTIVITY OR ACTION	PARTNERS INVOLVED
International organizations	Financial support	• Public Health England (Fleming Fund) • Robert Koch Institute • US CDC • World Bank • Canadian Foundation for Infectious Diseases • WHO
	Technical assistance in activity planning and implementation (AMR surveillance, diagnostic and antimicrobial stewardship, IPC, One Health, epidemic preparedness, and advice on cross-border and One Health infectious disease surveillance	• WHO • African Field Epidemiology Network (AFENET) • Africa CDC • US CDC • Public Health England
	Digitalization of sentinel sites for AMR surveillance	• Robert Koch Institute
National ministries and research centers	Regulatory activities • AMR coordinating body established at NCDC • AMR national surveillance coordinating body formed • One Health AMR Technical Working Group formally inaugurated at NCDC to conduct situation analysis on AMR; Nigeria enrolled in GLASS • Development of NAP for AMR • National AMR policy ongoing • Strengthening of import regulations to assure drug quality • Update of national drug policy to include AMR and antimicrobial stewardship • Draft of the national antimicrobial stewardship plan • Adoption of WHO AWaRe (access, watch, reserve) classification and update of essential drug lists and standard treatment guidelines	• Federal Ministries of Health, Agriculture, and Environment • NCDC • National universities • National Agency for Food and Drug Administration and Control • FMARD

Case Study 2 **Nigeria**

	Capacity-building activities • AMR awareness raising through education information and training • Strengthening of AMR surveillance system for human health by equipping laboratories and training workers in quality assurance for AMR detection and surveillance and by enrolling more laboratories in GLASS • Implementation of antibiotic stewardship programs at all levels • Implementation of IPC committee in designated health facilities • Tricycle One Health surveillance • Mobilization of stakeholders and communities by COP to improve awareness, build capacity, and advocate for AMR • Support by FMARD for the World Organisation for Animal Health (WOAH) Performance of Veterinary Services Follow-up Mission (report from this mission is publicly available and has also been circulated with relevant stakeholders)	• NCDC • Federal Ministries of Health, Agriculture, and Environment • WHO • Robert Koch Institute • Fleming Fund
Research centers	Targeted research studies • Point Prevalence Survey on Antimicrobial Use • National Antimicrobial Stewardship work plan according to NAP and Joint External Evaluation benchmark • Antimicrobial stewardship needs assessment • Antimicrobial consumption surveillance in pharmacies across many states in Nigeria	• NCDC • Local researchers • Various international partners
Community groups and local organizations	Targeted awareness raising and education by student and university groups, especially during World Antibiotic Awareness Week	• University of Ibadan • Africa One Health Network (AfOHNet)
	Webinars, policy advisory	Private organizations

Source: World Bank.

Note: CDC = Centers for Disease Control and Prevention; COP = Community of Practice; FMARD = Federal Ministry of Agriculture and Rural Development; GLASS = Global Antimicrobial Resistance and Use Surveillance System; IPC = infection prevention and control; NCDC = Nigeria Centre for Disease Control; WHO = World Health Organization.

Case Study 2
Nigeria

Enablers of progress

International partnerships allow for the mobilization of resources, technical exchange, collaborative project implementation, and institutional capacity building to strengthen laboratories and consequently improve patient care, AMR surveillance, and diagnostic stewardship. The implementation of action plans to address AMR depends on the efforts of many actors within the country and on the support of several international organizations, especially in the animal and human health sector (e.g., the Fleming Fund and the WHO). The focus here will be on the remarkable contributions of the RKI's NiCaDe project and the World Bank's REDISSE project, in addition to some in-country efforts.

Through the NiCaDe project, the RKI has supported NCDC by strengthening laboratory capacity in selected secondary hospitals through pilot models for diagnostic stewardship. This multiyear project supports structures and processes to enhance quality assurance in AMR diagnostics, surveillance, multidisciplinary communication, data digitalization, and equipment and material procurement. The project was co-conceived by both partners, but NCDC led the implementation of the project to accommodate predefined local priorities and to contribute knowledge of the local context. This approach has facilitated the achievement of the expected project outputs so far. The project also funded guest residency of Nigerian AMR program managers and senior laboratory staff at the RKI Berlin. They gained the required knowledge and skills to support national AMR control efforts further. This clear identification of partners' strengths promotes mutual respect and the overall success of the ongoing projects.[45]

The World Bank–funded REDISSE project supports the One Health framework in Nigeria by building capacity for disease surveillance and epidemic preparedness. The REDISSE project funds the development of high-quality public health and veterinary laboratories to facilitate emergency disease response. This component of the project has strengthened systems, laboratory capacity, and disease response in Nigeria. Nigeria's involvement in the REDISSE project is also generating data on animal health activities necessary for policy implementation and intervention designs.

Highly committed local institutions, and strong and stable leadership at the NCDC in particular, have strengthened local institutional capacity for AMR. Aside from cross-sectoral governance and capacity building led by the NCDC, the National AMR Coordination Committee and Animal Health Technical Working Group are in place to support AMR activities. NCDC continues to organize training and education opportunities for laboratory, clinical, and animal health staff locally and in the context of international scientific partnership. In particular, FELTP brings together medical, animal, and environmental science professionals who continue to provide personnel to support AMR field activities. The recent designation of NVRI as the NRL for animal health that oversees surveillance of AMR in food systems, livestock, poultry, aquaculture, and other related sectors is a step in the right direction for addressing AMR and a sign of progress.

The Nigerian NAP for AMR has provided a clear framework for implementing AMR activities and links strongly with the Global Action Plan's five core work packages (awareness creation, surveillance, antimicrobial stewardship, infection prevention, and research) (WHO 2015). The Global Action Plan was endorsed by the World Health Assembly in May 2015 to tackle the growing problems of antimicrobial resistance globally. The Nigeria NAP, however, highlights the strengths, weaknesses, opportunities, and threats of the AMR situation in Nigeria and outlines the governance structure from within the Nigerian ecosystem that oversees AMR-related activities and interventions.

45 Details about and insight into the RKI-funded NiCaDe project in Nigeria are from Dr. Olaniyi Ayobami of the Robert Koch Institute, Germany.

Case Study 2 **Nigeria**

This clear roadmap of action plans allows for strategies that will prevent, reduce, or slow down the spread of resistant pathogens in the country and facilitate a strong alignment of locally identified priorities with external resources and technical support. A review of the Nigeria NAP (2017–2022) is currently ongoing to assess progress and determine next steps for the subsequent edition of the Nigeria NAP.

A variety of institutions and agencies have contributed to increased AMR awareness among human and animal health professionals by engaging these professionals in AMR and One Health activities, such as World Antimicrobial Awareness Week. The NCDC also coordinates a National One Health Antimicrobial Resistance/Antimicrobial Use COP with the support of the Fleming Fund. The COP is meant to provide a social learning platform for formal and informal stakeholders who work in human, animal, and environmental health who wish to collaborate, share ideas, and find solutions to the challenges of AMR. In Nigeria, the human resource base for One Health is also increasing as the dangers of reducing antibiotics' effectiveness become more evident and as opportunities for training on AMR proliferate.

Challenges and barriers to success

Political commitment and funding **are still a major barrier to pushing forward AMR prevention and control activities in Nigeria.** A strong political commitment can guarantee adequate funding and the requisite legislative actions to address AMR across sectors. This is true in a socially complex setting with several structural and systemic weaknesses in governance and law enforcement. The Nigerian government still needs to make a significant investment and allocate a substantial part of its budget to strengthen the country's laboratories and health systems. The current budgetary allocation to health in Nigeria (about 7 percent as of 2021) is not enough to cater for the ever-growing Nigerian population. It falls short of the Abuja Declaration of 2001 that requires governments to allocate 15 percent of their budget to the health sector. The poor political commitment has stifled the mobilization of adequate funds, especially given the competing demand for limited resources and the dwindling government revenue. With the decreasing revenue from oil sales, the government is actively seeking other sources of revenue while cutting down funding in some sectors that are most in need of sustained funding. Dependence on donors thus becomes unavoidable in the absence of significant local funding. One of the main issues behind the low funding of AMR projects in Nigeria is that there could be inadequate economic case models for investment in AMR. Such models are needed to capture the AMR burden and convey its impact on AMR-related productivity losses affecting the country's economy. Political will—demonstrated via tailored engagements and innovative financing through local financing instruments—is important to get the message through and stimulate action.

Socioeconomic realities **of poverty and unemployment present an ethical dilemma for strict enforcement of regulated antibiotic use that is critical to counter the emergence of resistant infections in the community.** Many people in urban and rural communities access antibiotics through open markets and poorly regulated patent medicine vendors. The nonprescription use of antibiotics is a widespread driver of selective pressure. The nonprescription sale of antibiotics is poorly regulated, though it remains part of the economic life of many local communities, where it is a common source of livelihood. This situation points to the need for stronger law enforcement around the sale and use of medicines in Nigeria, along with economic initiatives addressing poverty and unemployment. An additional challenge is the lack of access to antimicrobials—especially second-line antibiotics—when the first-line antibiotic is ineffective. This drives the emergence and spread of resistant infections.

Case Study 2 **Nigeria**

As in most LMICs, *weak health systems* are another challenge; a resilient health system is needed to sustainably confront AMR, as resistant infections exert organizational and financial pressures that are resource intensive. The Nigerian health system is bedeviled with perennial challenges of weak funding, weak governance, and a rural-urban disparity in human resources, made worse by the surging brain drain in recent years. According to estimates in the 2017 NCDC situation analysis on antimicrobial use and AMR, only about 6 percent of the public health facilities in Nigeria have functional laboratories, while only one-third of these laboratories have qualified personnel to handle diagnostic tasks (Federal Ministries of Agriculture, Environment, and Health 2017a). Few personnel are trained in AMR laboratory surveillance, and the infrastructure to support genomic surveillance of emerging and circulating resistant infections is limited. Setting up such laboratory systems and infrastructure to ensure quality assurance is expensive and usually beyond the reach of low-resource countries without innovative strategies to leapfrog the adoption of these emerging diagnostic technologies. It is imperative to take actionable steps to address this challenge; these should include increasing laboratory capacity, securing a supply chain to ensure availability of laboratory reagents for priority AMR pathogens detection, and establishing AMR trainings to support in-country AMR surveillance programs.

***Sectoral integration and standardization of methods* are inadequate; the animal, human, and environmental health sectors are traditionally fragmented, and the individual disciplines employ different strategies.** Policy planning and coordination are conducted with the stakeholders in the FMOE and FMARD, but at the operational level, the majority of the AMR projects the NCDC superintends are in the human health sectors. The animal and environmental sectors in Nigeria are yet to benefit from adequate funding for AMR-related projects. The insufficient inclusion of the environmental and agricultural sectors might be linked to poor awareness of the contributions of these sectors in mitigating the spread of AMR, to lack of tools, or to risk-mapping standards. In many respects, data sharing on surveillance methods is not yet standardized or integrated. In addition, there are still challenges with defining roles for the major players in the FMOE regarding surveillance and control of AMR pathogens. Shifting emphasis from a human-centric approach to a true One Health approach will require sustained engagement, standardization of methods, and new tools.

***Data-related challenges* are pervasive; there are particular challenges with quality-assured AMR data and its linkage with clinical data on the one hand and its interoperability on the other.** The available data are limited and suffer from quality challenges, including bias, duplication, lack of timeliness, and lack of intersectoral linkages, thereby limiting the potential of the available data for greater impact across sectors. Specific challenges include the dearth of data on antimicrobial use across sectors but especially in the animal sector; multiple factors are responsible for this situation, including a poor or absent regulatory framework and limited coordination with the private sector, livestock owners, and crop farmers. A lack of standards and tools compounds the problem. Other sector-specific challenges include the absence of a national animal identification and traceability system, which leaves livestock farming practices and ownership unregulated. There is also poor delineation of roles and responsibilities in subsectors like the food systems, where multiple agencies still have overlapping responsibilities and sometimes work at cross-purposes. Without coordination of and support for AMR researchers under a defined local AMR research agenda, it will be challenging to bridge data gaps and build the evidence needed to engage policy makers and galvanize public health actions. To address this challenge, much more needs to be done to improve data capture, storage, and use through modern technologies and information systems in laboratories and hospitals in the human, animal, and environmental sectors. This may also include developing standard operating procedures for verification and identifying an external quality assessment provider for the NRL.

Case Study 2
Nigeria

Takeaways for the benefit of other teams planning to implement similar or related interventions

To achieve improved population health outcomes, especially in low- and middle-income countries, health policies and strategies must address locally determined priorities in a way that also addresses the sociocultural underpinnings of the issue, and policies and strategies must be implemented in a way that ensures impact and sustainable ownership. For other teams planning to implement an intervention similar to the REDISSE or RKI project, the following recommendations might prove helpful:

1. **Align the intervention with predefined local action plans and strategies.** This is important to ensure that priority activities are funded and implemented so as to promote resource efficiency and achieve expected outputs and impact on population health. RKI keyed into defined priorities of the NCDC in addressing gaps in AMR surveillance and antimicrobial stewardship. By doing so, it was able to align the historical competencies of RKI in AMR surveillance with the desire of the NCDC leadership to strengthen the national surveillance system for high-quality and representative AMR data. This strategic mutual interest has fostered the needed cooperation and continuous exchange at the highest level of health sector leadership in Nigeria and Germany.

2. **Consider building sustainability strategies.** The REDISSE project has ensured its sustainability in part by including the government, practitioners, communities, and other stakeholders at the conception and planning stages of the project. It also established a sustainable plan that thinks beyond the funding cycle by empowering, training, and supporting the recipient country to take ownership and lead the project. Also relevant is the scientific cooperation between RKI and NCDC, which provides funding to the NCDC to manage the staff recruitment, material procurement, and the project's field implementation. At the same time, RKI offers technical support for research, tools development, and overall project implementation. The laboratories in model sites are being designed to serve as hubs to provide high-quality microbiological services to other catchment hospitals in a defined geographical range; the goal is to pool finances for regular procurement of consumables and other low-level logistics sustainably beyond project lifespan. Furthermore, to complement external support, promote sustainability, and lessen dependence on donor funding, local communities (individuals and organizations) should be engaged to mobilize local resources beyond government funding. The NCDC-RKI diagnostic stewardship project identified many local experts, including those from the selected hospitals, to lead training where appropriate.

3. **Promote local research and professional bodies (such as medical associations and other allied professional societies) to engage policy and actions.** Locally generated evidence is needed to engage policy makers, develop solutions, prioritize interventions, and allocate resources for impact. Where possible, teams can support or fund proofs-of-concept that are adapted to contextual realities and that provide templates for scaling up and wider adoption. Opportunities must be provided to share learning experiences across sectors with communities and policy stakeholders through dissemination feedback and policy briefs. Where feasible, international partnerships should support knowledge translation and incorporate existing structures and processes beyond the national level to include regional and local health systems.

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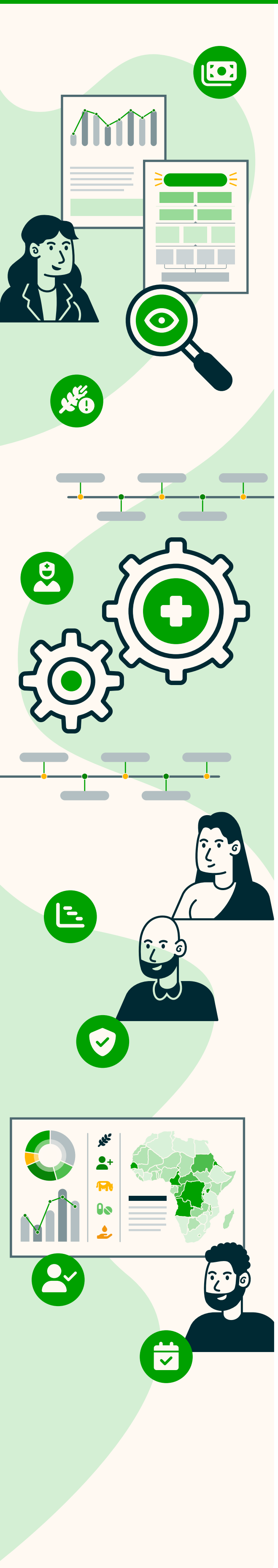
Chapter 6
Tools to Support the Design and Implementation of Operations

Costing and financing have been identified as a challenge to addressing AMR in low- and middle-income countries…a range of tools exist that can be used to support the prioritization and leadership of sectors in mobilizing investments.



Chapter 6
Tools to Support the Design and Implementation of Operations

Chapter 6 summary

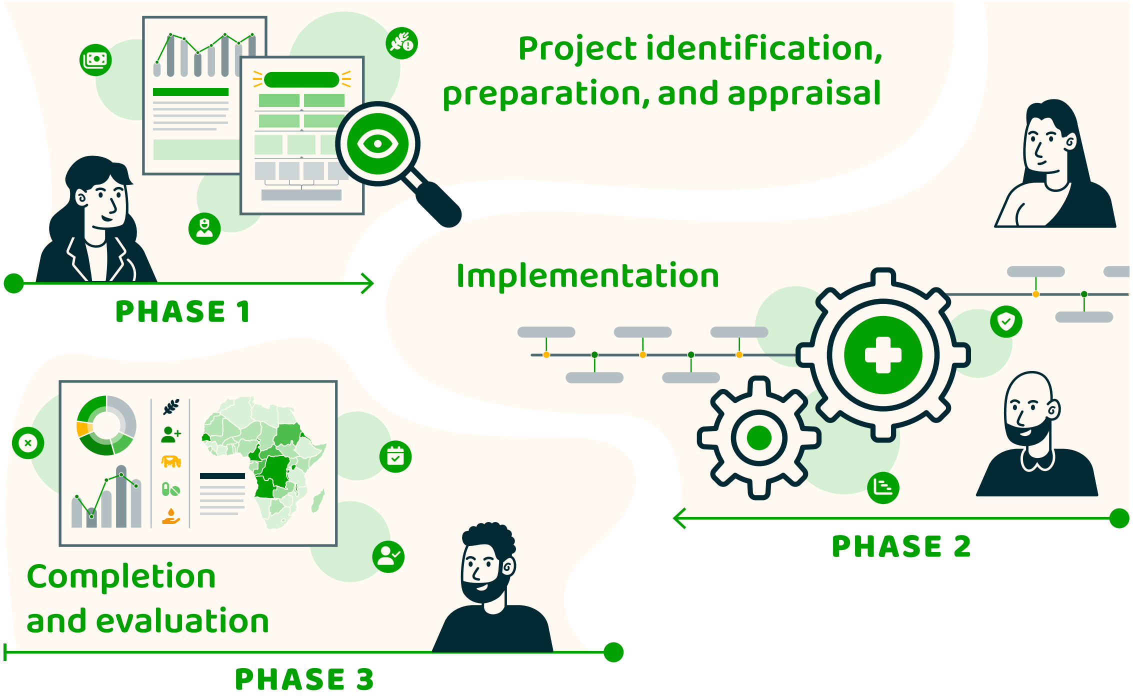
In 2021, the World Bank published a Landscape Analysis of Tools to Address Antimicrobial Resistance (AMR). This chapter draws on that work to provide task teams and clients with guidance on the range of tools that can be used to support project design and implementation. The Landscape Analysis of Tools identified over 90 tools for supporting investments in AMR. This chapter organizes the tools in terms of the project cycle across three categories: project identification, preparation, and appraisal; implementation; and completion and evaluation.

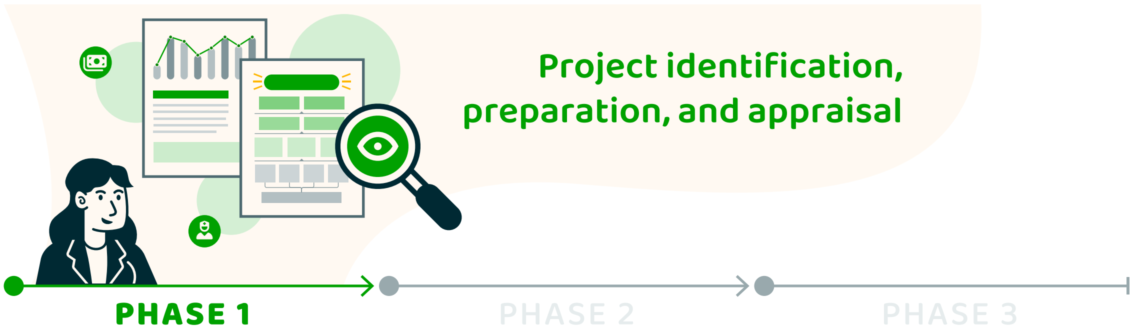
Costing and financing have been identified as a challenge to addressing AMR in low- and middle-income countries (LMICs), and this chapter highlights tools that can be used for costing interventions. In 2020, the World Health Organization (WHO) found that only 20 percent of National Action Plans (NAPs) were fully funded, and 40 percent had a budgeted operational plan (WHO 2021c). Successive Joint External Evaluation (JEE) reports have also highlighted a gap in financing for health security, particularly for AMR. This chapter therefore highlights a range of tools that can be used to support the prioritization and leadership of sectors in mobilizing investments.

Introduction

The World Bank's (2021) Landscape Analysis of Tools to Address AMR identified over 90 tools for supporting investments in AMR. The review identified six domains for actions and interventions focused on AMR: (i) awareness raising; (ii) antimicrobial stewardship; (iii) sur-veillance; (iv) infection prevention and control (IPC) in human and animal health; (v) the reduction of pathogen spread in the environment; and (vi) development of a national research agenda. These domains cut across human, animal, and environ¬mental health and key sectors—health, agriculture, environment and water, sanitation, and hygiene—that are all part of a multisectoral approach. Certain domains were well covered by the tools identified in the review, including surveillance interventions (46 out of the 90 tools), IPC (34 out of 90), and stewardship policies and intervention options (34 out of 90). In contrast, only 13 tools considered the spread of pathogens in the environment; five of these looked at the issue in detail, and the remaining eight looked at broader concerns related to the issue.

This chapter aims to provide task teams and clients with guidance on the range of tools that are available and offer suggestions about how they might be drawn upon in the design and implementation of operations. The Quadripartite organizations—WHO, World Organisation for Animal Health (WOAH), and Food and Agriculture Organization of the United Nations (FAO)—along with the United Nations Environment Programme (UNEP) and other institutions have developed a wide range of global, regional, and country-level tools that are designed to support countries in addressing AMR. At the relevant points in the project cycle, these tools can ensure that sector- and country-specific actions to target AMR are integrated appropriately into World Bank–financed projects. The chapter provides a list of the tools (updated since the Landscape Analysis in 2021). To support task teams and clients in selecting from among available tools, it organizes the tools into three categories related to the project cycle: identification, preparation, and appraisal; implementation; and completion and evaluation (see Table 14). The chapter also highlights certain tools across each project category to assist countries and implementers in leveraging the most essential tools from the range of options and in streamline their decision-making processes.





Phase 1: Project identification, preparation, and appraisal

Tools in this grouping can be used for project identification—specifically to assess the technical, economic, social, and environmental aspects of a proposed project, to outline project theories of change, and to assess project feasibility. Box 11 provides a snapshot of "first-line" or highlighted tools in this category. The revised International Health Regulations (IHR) require all IHR State Parties to evaluate minimum national core capacities for surveillance and response as specified in the IHR, and to develop a plan of action to ensure that these capacities are functional and up to date. In the human health and animal health sectors, functions associated with early detection, proper management, and early response to public health emergencies of international concern (PHEICs) rely on the health security framework laid out under the IHR. Tools such as the Joint External Evaluation and the Performance of Veterinary Services (PVS) Pathway reports can help clients to assess capacities in the human and animal sectors, and to outline gaps, operational weaknesses, and strengths. Where there is appetite for a multisectoral approach, bringing the results of the JEE and the PVS together in a bridging workshop can help countries prioritize investments and plan for collaborative implementation at an early stage.

Box 11. Highlighted Tools within the Project Identification, Preparation, and Appraisal Category

Highlighted Tools within the Project Identification, Preparation, and Appraisal Category

The JEE has been deployed as a tool to assess a country's capacity to prevent, detect, and rapidly respond to public health risks (WHO 2023). The JEE tool helps countries self-identify critical gaps within their human and animal health systems to prioritize opportunities for enhanced preparedness and response, and to match gaps with resources. The tool is designed to be implemented by host country governments in collaboration with national experts and external teams of international subject matter experts. The tool assesses 19 technical areas divided among four categories and using 49 underlying indicators.

The PVS Pathway is a voluntary, multistage, continuous process that uses a set of complementary tools to help veterinary services improve their capacity to undertake their animal health, veterinary public health, and other regulatory functions in closer compliance with the international standards of the WOAH codes (WOAH 2019). The PVS Pathway advances a strong systems approach and supports the strengthening of the multisectoral capacities needed for the control of zoonoses, food safety, and AMR. The PVS Pathway assesses the performance of a country's veterinary services and their compliance with the WOAH intergovernmental standards on the quality of veterinary services. It reviews all aspects relevant to the Terrestrial Code and the quality of veterinary services according to the WOAH's definition.

The WOAH's List of Antimicrobials of Veterinary Importance was developed to safeguard the efficacy and availability of veterinary antimicrobial products for animal diseases where there are few or no alternatives (WOAH 2018). The list's additional aims are to help veterinarians in their choice of the appropriate therapeutic agent, to complement the WOAH guidelines for responsible and prudent use of antimicrobial agents, and to serve as a useful information base to support science-based risk assessment of antimicrobial resistance.

The FAO Assessment Tool for Laboratories and AMR Surveillance Systems (FAO-ATLASS) helps countries evaluate their AMR surveillance systems and build surveillance capacity (FAO 2020a). The tool maps the national AMR surveillance systems along five pillars—laboratory capacity and network, epidemiology unit, governance, communication, and sustainability. The tool consists of two modules—laboratory and surveillance—that include features of FAO's Laboratory Mapping Tool (LMT) and Surveillance Evaluation Tool (SET), focusing on AMR. FAO-ATLASS provides recommendations for improving the systems, measures progress relative to the FAO Global Action Plan, and provides evidence for action and advocacy.

The Methodology for the Analysis of AMR-Relevant Legislation in the Food and Agriculture Sector (Guidance Document for Regulators)[46] is a tool that allows countries and regional organizations to identify, analyze, assess, and potentially improve their regulatory frameworks to better meet their AMR objectives (FAO 2020c; see also FAO 2020b).[a] It addresses (i) regulation of antimicrobials, including veterinary medicinal products and pesticides; (ii) protection of food and the environment against antimicrobial and AMR contamination; and (iii) prevention of AMR through healthier and more resilient ecosystems. The methodology has been used in more than 26 countries and by a regional organization. It will be upgraded with a One Health AMR Legal Assessment Tool (currently under development by FAO, WHO, and the WOAH) that will assess the status of legislation on AMR and outline gaps in governance of AMR.

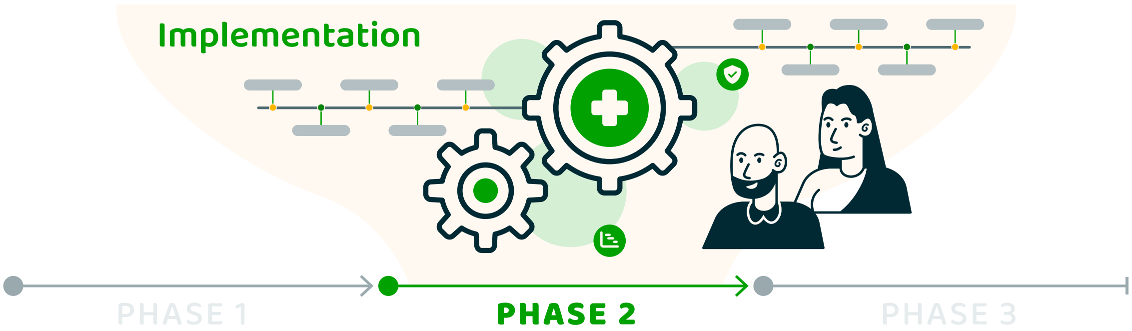
The WHO AWaRe Tool[47] aims to promote the use of narrow-spectrum antibiotics for common infections and to reserve broad-spectrum antibiotics for the most challenging infections.[b] This tool provides recommendations on appropriate antibiotic choices for 21 common infections. It categorizes antibiotics into three groups. The access category comprises the preferred narrow-spectrum antibiotics for the most common infections. The majority of antibiotics in this group are β-lactams (52.63 percent), followed by aminoglycosides (15.78 percent), macrolides (5.26 percent), and tetracyclines (5.26 percent). The watch category comprises antibiotics that are reserved for specific and limited indications and are more susceptible to antibiotic resistance. They are preferred over access antibiotics in the treatment of severe infections. The largest share of antibiotics in the watch group are β-lactams (54.54 percent), followed by macrolides (18.18 percent), aminoglycosides (9.09 percent), and carbapenems (9.09 percent). The reserve category includes antibiotics that should be used sparingly or as a last resort when other antimicrobial options have failed. The reserve group primarily consists of polymyxin (28.57 percent), followed by β-lactams (14.28 percent) and aminoglycosides (14.28 percent).

a. The selection of the cited tools as a focus was also validated in 2021 consultation with FAO.

b. World Health Organization, "WHO Antibiotic Categorization," https://aware.essentialmeds.org/groups.

46 Food and Agriculture Organization of the United Nations, "Containment of Antimicrobial Resistance in Terrestrial and Aquatic Food Production Systems, under the One Health Approach in Latin America," https://www.fao.org/antimicrobial-resistance/projects/completed/project-6/en/; see also FAO (2020b). The selection of these tools as tools for focus was also validated in the recent consultation with FAO.

47 World Health Organization, "WHO Antibiotic Categorization," https://aware.essentialmeds.org/groups.



Phase 2: Implementation

Tools in this grouping can inform implementation support (including the supervision of timelines, actions, and monitoring mechanisms). They can also inform assessments of progress toward the achievement of project objectives as well as measures for course correction. More broadly, they can facilitate the application of practical global, regional, and national lessons garnered at the human-animal-environment implementation interface. Box 12 provides a snapshot of first-line or highlighted tools in this group, which include the PVS Gap Analysis Tool, FAO's Progressive Management Pathway for AMR (FAO-PMP-AMR), FAO Legal Methodology tool, and National Action Plans on AMR.

Box 12. Highlighted Tools within the Implementation Category

Highlighted Tools within the Implementation Category

The Global Action Plan on AMR (WHO 2015) is a comprehensive framework developed by the World Health Organization to address the growing threat of antimicrobial resistance worldwide. The plan guides countries in implementing effective strategies to combat AMR across human health, animal health, and the environment. It emphasizes the importance of strengthening surveillance systems, promoting appropriate use of antimicrobials, enhancing IPC measures, and fostering research and innovation. The Global Action Plan serves as a critical roadmap for countries, fostering global collaboration on efforts to preserve the effectiveness of antimicrobial drugs and protect public health for future generations. Notably, the "Monitoring and Evaluation of the Global Action Plan on AMR" toolkit (WHO, FAO, and WOAH 2019) offers countries guidance in selecting and utilizing core indicators to effectively measure progress toward the Global Action Plan's objectives.

The Strategy on AMR and the Prudent Use of Antimicrobials (WOAH 2021) focuses on promoting responsible and judicious use of antimicrobials in animal health to minimize the emergence and spread of AMR. WOAH emphasizes the importance of surveillance, monitoring, and reporting of antimicrobial use in animals, along with implementing appropriate veterinary practices, including disease prevention and control measures. By advocating for the prudent use of antimicrobials in animals, the WOAH strategy aims to safeguard animal health and welfare along with public health, thereby contributing to global efforts to combat AMR and preserve the effectiveness of antimicrobial treatments for both humans and animals.

The FAO (2016) Action Plan on Antimicrobial Resistance was formulated to address the significant challenges posed by AMR in the agricultural sector. The plan focuses on promoting responsible and sustainable practices in animal and plant production systems, aquaculture, and crop farming. It emphasizes the need for improved surveillance systems, increased awareness, and capacity building to ensure the prudent use of antimicrobials in agriculture. The plan also advocates for enhanced biosecurity measures, improved animal welfare practices, and the development of alternatives to antimicrobials in animal production. By implementing the FAO Action Plan on AMR, countries can help mitigate the risks associated with AMR in the agricultural sector and protect human health, animal health, and the environment.

For the agriculture and food sectors, the Progressive Management Pathway for AMR (FAO-PMP-AMR) offers a staged process for guiding activities and interventions on AMR in the four focus areas of the FAO Action Plan and in alignment with the AMR Global Action Plan.[a] The FAO-PMP-AMR helps countries develop and operationalize the main food and agriculture components of their NAPs, ranging from small-scale, targeted interventions to national-level interventions. The process brings together public and private stakeholders to self-assess the level of NAP implementation in their country and agree on actions to escalate AMR management to a higher stage, as required. During FAO-PMP-AMR workshops, countries are assisted and guided in undertaking concrete steps toward implementing a multisector One Health NAP on AMR in line with the Global Action Plan. At the end of the workshop, progress in implementing the NAP is determined within the different focus areas and stages of the FAO-PMP-AMR; the capacities of the key national stakeholders on AMR management are strengthened, and the FAO-PMP-AMR tool is finalized for validation by the relevant stakeholders. Countries own the information generated from the workshops, and the assessment is maintained as confidential—that is, the tool is not meant for cross-country comparison. The FAO-PMP-AMR also complements other tools of the Tripartite organizations, such as the JEE, GLASS, PVS Pathway, and FAO-ATLASS.

The WHO (2022) AMR National Action Plan Implementation Handbook provides comprehensive stepwise guidance for implementing NAPs within the human health sector. It collates and summarizes existing WHO tools and resources to support countries with readiness assessments, governance and multisectoral coordination, activity prioritization, implementation tools across the Global Action Plan's strategic objectives, costing and budgeting of NAPs, resource mobilization, and monitoring and evaluation.

The modular WHO (2021c) National Action Plan costing and budgeting tool helps countries estimate costs and plan budgets for the prioritized activities outlined in their NAPs, with a specific focus on addressing AMR. This tool enables users to identify funding flows, assess budget gaps, and leverage user-friendly dashboards to advocate for additional resources as needed. The tool is complemented by a user guide, a comprehensive training package, and a web-based help desk, which foster collaboration and participation across multiple sectors. Having undergone successful piloting in Sierra Leone, Somalia, Jamaica, and Paraguay, the tool is now being rolled out on a broader scale and to a wider range of countries and regions.

The Tailoring Antimicrobial Resistance Programmes (TAP) Quick Guide (WHO 2021b) offers a step-by-step, practical approach to designing and implementing projects that address AMR in human and animal health through targeted behavior change. TAP is a behavioral change methodology developed to modify the behaviors that drive AMR. It aims to identify both barriers to proper behavior and incentives that drive certain behaviors. Accompanying the Quick Guide is a TAP Toolbox with exercises and tools to assist in each stage of project development.

a. See Food and Agriculture Organization of the United Nations, "FAO Progressive Management Pathway for Antimicrobial Resistance (FAO-PMP-AMR)," https://www.fao.org/antimicrobial-resistance/resources/tools/fao-pmp-amr/en/.

Phase 3: Completion and evaluation

Tools in this grouping can help to align information sharing and reporting with wider operational processes. Box 13 provides a snapshot of first-line or highlighted tools that have been included in this category; a more inclusive list of 100 tools is in Table 13. Tools such as TrACSS (the Tripartite AMR Country Self-Assessment Survey) and TISSA (Tripartite Integrated Surveillance System on AMR/ AMU [antimicrobial use]) platform can help to document the results achieved, the problems encountered, the lessons learned, and the knowledge gained from carrying out projects. The tools in this section can also inform the description and evaluation of final project outcomes, and they can help countries determine what additional measures and capacity improvements are needed to sustain the outputs derived from a project. For example, a tool like TrACSS—a multisectoral self-assessment questionnaire—helps to capture country information on capacity, coverage, and performance on key aspects of the AMR Global Action Plan. The Tripartite is also in the process of developing a mechanism for collecting multisectoral AMR data in an integrated system for surveillance, where data on antimicrobial use and resistance are integrated with data from the human health, animal health, plant, food, and environment sectors.

Box 13. Highlighted Tools in the Completion and Evaluation Category

Highlighted Tools in the Completion and Evaluation Category

The Tripartite Integrated Surveillance System on AMR/AMU is an integrated surveillance system that is being developed to monitor AMR and AMU/AMC (antimicrobial consumption) across the human-animal-plant-food-environment interface.[a] TISSA will link and reference current initiatives for AMR and AMU/AMC surveillance data across sectors at the regional and global levels. It will also leverage data from country surveillance and monitoring systems to capture and report AMR and AMU/AMC data in humans, animals, plants, food, and the environment.

The Tripartite Monitoring and Evaluation Framework and Recommended Indicators for implementation of the Global Action Plan (WHO, FAO, and WOAH 2019) aims to generate data to assess the delivery of the Global Action Plan's objectives and inform operational and strategic decision-making on AMR for the next five years. The framework is designed to assess the effectiveness of efforts to implement the Global Action Plan, including monitoring of results and evaluation of impact on various aspects of AMR action. TrACSS is aligned with the indicators of the framework and is delivered on an annual basis.

The Global Antimicrobial Resistance and Use Surveillance System (GLASS) (WHO 2020) was developed as a standardizing mechanism to identify indicators and set targets to monitor progress toward the AMR Global Action Plan across human health, animal health, and agriculture. Through the AMR module, GLASS provides a standardized approach for collection, analysis, interpretation, and sharing of data by countries, and monitors the status of existing and new national surveillance systems. GLASS has been updated to include a new component on AMC surveillance at the national level. GLASS now also includes a One Health module, based on the extended spectrum β-lactamase (ESBL) E. coli Tricycle project, which as of 2021 had been piloted in six countries. GLASS reports summarized data reported to WHO in the previous year. They include data on AMC surveillance and AMR data on laboratory-confirmed infections reported by surveillance sites in countries globally. The reports also describe developments related to GLASS and other AMR surveillance programs led by WHO, including resistance to anti-HIV and anti-TB medicines and antimalarial drug efficacy.

The FAO (2017) Surveillance Evaluation Tool addresses AMR surveillance in the agricultural sector. This tool serves as a valuable resource for countries seeking to assess and enhance their surveillance systems for AMR in animal and plant production, aquaculture, and crop farming. The FAO surveillance evaluation tool provides a standardized framework to evaluate the effectiveness, efficiency, and quality of AMR surveillance activities. It helps countries identify gaps in their surveillance systems, improve data collection and analysis, and strengthen their capacity for timely reporting. Countries can monitor the prevalence of AMR, track trends, and make informed decisions to mitigate the risks associated with AMR in agriculture, thereby safeguarding human and animal health and promoting sustainable agricultural practices.

a. See Arno Muller, "Tissa: The Tripartite Integrated System for Surveillance of AMR/AMU," slide presentation, https://www.ivi.int/wp-content/uploads/2022/04/Day_1_Arno_Muller_The_Tripartite_Integrated_System_for_Surveillance_of_AMR_AMU.pdf.

Table 13. List of Tools

TOOL	DESCRIPTION	ORGANIZATION	YEAR ISSUED/ LAUNCHED	SOURCE
1. Global Action Plan on AMR (GAP-AMR)	Benchmark tool that enables countries to devise a context-specific national action plan on AMR	World Health Organization (WHO)	*2015*	View
2. Strategy on AMR and the Prudent Use of Antimicrobials	Presents a top-level WOAH-specific strategy on actions to combat AMR	Organisation for Animal Health (WOAH)	*2016*	View
3. FAO Action Plan on Antimicrobial Resistance	FAO-specific plan to support the food and agriculture sectors in implementing GAP-AMR	Food and Agriculture Organization of the United Nations (FAO)	*2016*	View
4. FAO Assessment Tool for Laboratories and Surveillance Systems (FAO-ATLASS)	Assesses laboratories and antimicrobial resistance surveillance systems at national and regional levels	FAO	*2018*	View
5. Progressive Management Pathway for AMR (FAO-PMP-AMR)	Self-assessment tool that provides guidance for countries in developing and implementing a multisector One Health national action plan	FAO	*2019*	View
6. FAO Surveillance Evaluation Tool	Developed by FAO to provide countries with a comprehensive and standardized way to evaluate animal disease surveillance systems, including for zoonoses	FAO	*2017*	View
7. FAO Laboratory Mapping Tool (LMT)	Assesses the functionality of veterinary laboratories	FAO	*2015*	View
8. WHO AMR Stewardship Programmes in Health-Care Facilities and LMICs Toolkit	Provides guidance on core elements and structures that need to be in place at the national and facility level in low-resource countries to establish and support antimicrobial stewardship interventions	WHO	*2019*	View
9. Global Antimicrobial Resistance and Use Surveillance System (GLASS) tool and One Health module	Developed to facilitate and encourage a standardized approach to AMR surveillance globally and in turn support the implementation of the Global Action Plan on antimicrobial resistance	WHO	*2015; 2021 update*	View

TOOL	DESCRIPTION	ORGANIZATION	YEAR ISSUED/ LAUNCHED	SOURCE
10. AWaRe tool	Classifies antibiotics into three groups —access, watch, and reserve—and categorizes antibiotics in terms of common and serious infections, availability in the health care system, and sparing or last-resort use	WHO	*2019*	View
11. AWaRe Campaign: "Adopt AWaRe. Handle antibiotics with care."	Accompanying advocacy material to AWaRe tool for implementers and policy makers	WHO	*2019*	View
12. Antibiotic Prescribing and Resistance: Views from Low- and Middle-Income Prescribing and Dispensing Professionals	Report on awareness of AMR and knowledge of antibiotics within prescribing and dispensing settings across low- and middle-income (LMIC) contexts	WHO, Antimicrobial Resistance Centre at the London School of Hygiene and Tropical Medicine	*2017*	View
13. AMR Framework for Action Supported by the Interagency Coordinating Group on Antimicrobial Resistance (IACG)	Aims to support and accelerate the implementation of the GAP-AMR	Interagency Coordination Group on Antimicrobial Resistance	*2017*	View
14. WHO Situation Analysis	Provides an analysis of initiatives currently being implemented to combat AMR in all six WHO regions	WHO	*2015*	View
15. Antimicrobial Resistance: A Manual for Developing National Action Plans	Enables countries to devise a context-specific National Action Plan on AMR	WHO, FAO, and WOAH	*2016*	View
16. Country Progress on the Implementation of the Global Action Plan on Antimicrobial Resistance: WHO, FAO, and WOAH global tripartite database	Collects data on GAP-AMR and National Action Plan implementation progress	WHO, FAO, and WOAH	*2018*	View
17. WHO Competency Framework for Health Workers' Education and Training on Antimicrobial Resistance	AMR-related reference guide on training, skills, and knowledge for health professionals	WHO, FAO, and WOAH	*2018*	View
18. Strategic Research Agenda: Joint Programming Initiative on Antimicrobial Resistance	Platform for the coordination of programming research on AMR	Joint Programming Initiative on AMR	*2018*	View

TOOL	DESCRIPTION	ORGANIZATION	YEAR ISSUED/ LAUNCHED	SOURCE
19. Technical Brief on Water, Sanitation, Hygiene (WASH) and Wastewater Management to Prevent Infections and Reduce the Spread of AMR	Provides information on WASH and wastewater management for infection prevention	WHO, FAO, and WOAH	*2020*	View
20. Guidelines on Core Components of Infection Prevention and Control Programmes at the National and Acute Health Care Facility Level	Provides guidance to policy makers and facility-level administrators on IPC programs and infection prevention in clinical settings	WHO	*2016*	View
21. FAO Resource Package on Good Hygiene Practices	Set of resources that provide prescriptive guidance on good hygiene practices across food production sectors	FAO	*2020*	View
22. FAO Good Practices for Biosecurity in the Pig Sector	Describes biosecurity risks in developing countries and measures that can be taken to mitigate these risks along pig production and marketing chains	FAO	*2010; 2015 update*	View
23. Antimicrobials in Agriculture and the Environment: Reducing Unnecessary Use and Waste	Paper proposes three broad interventions to reduce the use of antibiotics in food production and curtail the consequential dispersion of resistant bacteria (through animal waste) into the environment	Review on Antimicrobial Resistance	*2015*	View
24. Monitoring and Evaluation of the Global Action Plan on Antimicrobial Resistance: Framework and Recommended Indicators	Aims to provide a manageable system that can facilitate the generation, collection, and analysis of standardized data to assess the success of the GAP-AMR and inform operational and strategic decision-making on AMR for the next 5–10 years at the national and global levels	WHO, FAO, and WOAH	*2019*	View
25. Tripartite AMR Country Self-Assessment Survey (TrACSS)	Collects data on GAP-AMR and National Action Plan implementation progress	WHO, FAO, and WOAH	*Annual*	View
26. FAOSTAT	System for collecting data on food and agriculture	FAO	*2015*	View

TOOL	DESCRIPTION	ORGANIZATION	YEAR ISSUED/ LAUNCHED	SOURCE
27. FAOLEX	A comprehensive and up-to-date legislative and policy database; one of the world's largest electronic collections of national laws, regulations, and policies on food, agriculture, and natural resources management	FAO	*Database*	*View*
28. FAO Methodology to Analyze AMR-Relevant Legislation in the Food and Agriculture Sectors	Provides guidance for legislators seeking to identify and analyze existing legislation relevant to AMR in a national legal system; highlights a list of regulatory areas with an impact on AMR	FAO	*2021*	*View*
29. WHO Benchmarks for International Health Regulations (IHR) Capacities	Lists benchmarks and corresponding actions to improve IHR capacities for health security and integrate multisectoral concerns at subnational (local and regional/provincial) and national levels	WHO	*2019*	*View*
30. Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS)	Provides policy makers and decision-makers with a reliable, easily accessible, comprehensive, and global analysis of relevant investments and enabling environment so they can make informed decisions on sanitation, drinking water, and hygiene	WHO	*2019*	*View*
31. AMR Benchmark	A benchmark to rank and guide pharmaceutical company action on drug resistance	Access to Medicines Foundation	*Annual*	*View*
32. WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene	Global portal for global WASH data	WHO, United Nations Children's Fund (UNICEF)	*Database*	*View*
33. WHO Hand Hygiene Self-Assessment Framework and WHO Infection Prevention and Control Assessment Framework	Enables a situation analysis of hand hygiene promotion and practices within an individual health care facility, according to a set of indicators; acts as a diagnostic tool, identifying key issues requiring attention and improvement	WHO	*Annual*	*View*

TOOL	DESCRIPTION	ORGANIZATION	YEAR ISSUED/ LAUNCHED	SOURCE
34. WOAH PVS Pathway	Toolkit for the sustainable improvement of national veterinary services; provides a comprehensive understanding of services' strengths and weaknesses using a globally consistent methodology	WOAH	*Cyclical*	View
35. STAR-IDAZ International Research Consortium	Platform that coordinates animal health research globally to accelerate delivery of disease control tools and strategies	International Research Consortium on Animal Health	*2016*	View
36. WHO Model Lists of Essential Medicines (20th list)	Report on the recommendations of the WHO Expert Committee on the Selection and Use of Essential Medicines for the 2019 Essential Medicines Lists	WHO	*2019*	View
37. ReAct Online Toolbox for National Action Plans	Resource package to support countries in the development and implementation of National Action Plans, utilizing a One Health approach	ReAct	*Annual*	View
38. Declaration by the Pharmaceutical, Biotechnology and Diagnostics Industries on Combating Antimicrobial Resistance	Declaration signed by 85 companies and 9 industry associations on priority actions against drug resistance, including creation of sustainable antibiotic market models	International Federation of Pharmaceutical Manufacturers' Associations (IFPMA)	*2016*	View
39. Tackling Antimicrobial Resistance: Ensuring Sustainable R&D	Paper on potential actions (and G7/G20 roles) to amplify sustainable research and development for antimicrobial therapies	OECD (Organisation for Economic Co-operation and Development), WHO, FAO, and WOAH	*2017*	View
40. World Antibiotic Awareness Week: Monitoring & Evaluation Report	Report on the country and regional level outcomes of the 2018 World Antibiotic Awareness Week	WHO	*Annual*	View
41. Guidelines for the Prevention and Control of Carbapenem-Resistant Enterobacteriaceae, Acinetobacter baumannii and Pseudomonas aeruginosa in Health Care Facilities	Global guidelines for the prevention and control of carbapenem-resistant Enterobacteriaceae, Acinetobacter baumannii, and Pseudomonas aeruginosa, which are emerging causes of health care–acquired infections	WHO	*2017*	View

TOOL	DESCRIPTION	ORGANIZATION	YEAR ISSUED/ LAUNCHED	SOURCE
42. Global Framework for Development & Stewardship to Combat Antimicrobial Resistance: Draft Roadmap	Outlines the current AMR situation and options for establishing a global framework on the development, control, and use of antimicrobial medicines, diagnostics, and other interventions	WHO	*2017*	View
43. WASH in Health Care Facilities: Practical Steps to Achieve Universal Access to Quality Care	Presents eight practical actions that governments can take at the national and subnational levels to improve WASH services in health care facilities	WHO	*2019*	View
44. WASH in Health Care Facilities: Global Baseline Report	Establishes national, regional, and global baseline estimates for WASH services in health care facilities	WHO, UNICEF	*2019*	View
45. Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines	Paper presents estimates of population with access to "safely managed" drinking water and sanitation services	WHO, UNICEF	*2017*	View
46. Library of National Action Plans	A library of existing, publicly available National Action Plans on antimicrobial resistance	WHO	*2015*	View
47. AMR National Action Plan Support Tools	Resource materials for the development and implementation of National Action Plans	WHO	*2015*	View
48. Global Priority List of Antibiotic-Resistant Bacteria to Guide Research, Discovery, and Development of New Antibiotics	Outlines a global priority pathogen list of antibiotic-resistant bacteria as a useful input for research on and development of antibiotic treatments	WHO	*2017*	View
49. Diagnostic Stewardship: A Guide to Implementation in Antimicrobial Resistance Surveillance Sites	A GLASS companion tool to support microbiological diagnosis, including antimicrobial susceptibility testing	WHO	*2016*	View
50. Africa CDC Antimicrobial Resistance Surveillance Network (AMRSNET)	Africa-specific regional approach to surveillance that aims to improve mechanisms to monitor and delay AMR emergence and limit AMR transmission	Africa Centres for Disease Control and Prevention (CDC)		View
51. Africa Regional Strategy on AMR Communication and Advocacy	Africa - specific regional approach to advocacy and communication on AMR, particularly on prudent use and animal husbandry practices	FAO, WHO, WOAH, UNEP, African Union	*2021*	View

TOOL	DESCRIPTION	ORGANIZATION	YEAR ISSUED/ LAUNCHED	SOURCE
52. Estimating the Economic Costs of Antimicrobial Resistance: Model and Results	Global economic burden study on the costs and direct and indirect impacts of AMR	RAND Corporation, Independent Review on AMR	*2014*	View
53. Antibacterial Agents in Clinical Development: An Analysis of the Antibacterial Clinical Development Pipeline, Including Tuberculosis	Annual review of the alignment of the clinical antibacterial pipeline to the WHO priority pathogens list	WHO	*2017*	View
54. PVS Gap Analysis Tool	Companion planning and costing tool for the PVS Pathway tool	WOAH	*Cyclical (launched in 2013)*	View
55. Resistance Map	Collection of charts and maps that summarize national and subnational data on antimicrobial use and resistance globally	Center for Disease Dynamics, Economics and Policy	*Up-to-date: 2023*	View
56. Health Workers' Education and Training on Antimicrobial Resistance: Curricula Guide	AMR-related curricula guide on training, skills, and knowledge for health professionals	WHO	*2019*	View
57. The Structured Operational Research and Training IniTiative (SORT IT) on AMR, coordinated by the Special Programme for Research and Training in Tropical Diseases (TDR)	Program on AMR being implemented in 36 operational research studies in five countries (Ghana, Uganda, Sierra Leone, Myanmar, and Nepal)	UNICEF, United Nations Development Programme (UNDP), World Bank, WHO	*2019*	View
58. Integrated Surveillance of Antimicrobial Resistance	Guidance document on efforts to minimize the impact of AMR associated with the use of antimicrobials in food animals	WHO	*2017*	View
59. The 6th Annual WOAH Report on Antimicrobial Agents Intended for Use in Animals	Annual report on global data on the use of antimicrobial agents in animals	WOAH	*Annual*	View
60. Tackling Antimicrobial Resistance Together: Working Paper 5.0: Enhancing the Focus on Gender and Equity	Paper outlining gender and equity considerations as countries address AMR	WHO	*2018*	View

TOOL	DESCRIPTION	ORGANIZATION	YEAR ISSUED/ LAUNCHED	SOURCE
61. Summary Report of the FAO/WHO Expert Meeting on Foodborne Antimicrobial Resistance: Role of Environment, Crops and Biocides	Report outlining scientific advice on the transmission of antimicrobial-resistant bacteria from environmental sources to foods and feeds of plant and aquatic animal origin	FAO, WHO	*2018*	View
62. The Environment as a Driver of Antibiotic Resistance	Platform for coordinated research on AMR and the environment focused on sources and drivers and on mitigation	Centre for Antibiotic Resistance (CARe), University of Gothenburg, Swedish Research Council	*2019*	View
63. Frontiers 2017: Emerging Issues of Environmental Concern	Report on key emerging issues, including the environmental dimension of AMR	United Nations Environment Programme (UNEP)	*2017*	View
64. Preventing the Next Pandemic – Zoonotic Diseases and How to Break the Chain of Transmission	Report on the root causes of emergence and spread of zoonoses	UNEP	*2020*	View
65. Reframing Resistance	Toolkit on impact communications for AMR (for experts, communicators, and practitioners)	Wellcome Trust	*2020*	View
66. Gulf–Middle East–North Africa Antimicrobial Stewardship Network	Middle East and North Africa–specific educational platform for antimicrobial stewardship and related resources	British Society for Antimicrobial Chemotherapy	*2020*	View
67. Tackling Antimicrobial Resistant Together: Working Paper 1.0: Multisectoral Coordination	Practical guidance on establishing and sustaining multisectoral coordination in the implementation of National Action Plans for AMR	WHO	*2018*	View
68. An Analysis of the Animal Human Interface with a Focus on Low- and Middle-Income Countries	Report outlines antimicrobial use and AMR in livestock and farmed aquatic species in LMICs; includes recommendations for surveillance and research	Fleming Fund, Wellcome Trust	*2016*	View
69. Joint External Evaluation (JEE) tool and reports	Tool assesses country capacities and capabilities relevant to the 19 technical areas of JEE; provides baseline data and recommendations to improve public health security and comply with the IHR	WHO	*Cyclical*	View

TOOL	DESCRIPTION	ORGANIZATION	YEAR ISSUED/ LAUNCHED	SOURCE
70. Global Research on Antimicrobial Resistance (GRAM) Project	Facilitates the generation of accurate and timely evidence on AMR burden globally	University of Oxford Big Data Institute–Institute for Health Metrics and Evaluation (IHME) Strategic Partnership	*2017*	View
71. International Instruments on the use of Antimicrobials across the Human, Animal and Plant Sectors	Book by the Tripartite organizations providing an overview and analysis of international instruments that outline standards related to the use of antimicrobials across the human, animal, and plant sectors	WHO, FAO, and WOAH	*2020*	View
72. US CDC Laboratory Assessment of AMR Testing Capacity (LAARC)	Laboratory assessment tool for use in clinical bacteriology laboratories in LMICs; helps laboratories identify and correct laboratory practices that contribute to inaccurate antibiotic resistance data	US Centers for Disease Control and Prevention (CDC)	*2020*	View
73. Guidelines for the Development of National Action Plan for Health Security	Outlines a three-step approach to help countries plan and implement priority actions to attain health security; builds on and refers to all existing policies, agreements, strategies, and frameworks at the national, regional, and global levels; designed to be used by countries to facilitate multisectoral National Action Plans	WHO	*2018*	View
74. Industry Alliance against AMR Progress Report	A snapshot of the life sciences industry's collective efforts and leadership in tackling AMR—in the areas of research and science, access, appropriate use, and environmental manufacturing	AMR Industry Alliance	*Annual*	View
75. The Industry Roadmap for Progress on Combating Antimicrobial Resistance	Lays out key commitments for combatting AMR and consolidating stewardship of antibiotics	International Federation of Pharmaceutical Manufacturers and Associations	*2016*	View
76. Time is Running Out Technical Note	Outlines UNICEF's AMR-related programming and related partnerships with governments and other stakeholders	UNICEF	*2019*	View

TOOL	DESCRIPTION	ORGANIZATION	YEAR ISSUED/ LAUNCHED	SOURCE
77. WOAH Data Collection Template and Related Guidance	Template for collecting data on antimicrobial agents intended for use in animals	WOAH	*2020*	View
78. Core Elements of Human Antibiotic Stewardship Programs in Resource-Limited Settings	Provides a template (core elements) to optimize antibiotic prescription in resource-limited hospital settings	US CDC	*2019*	View
79. ACORN (Clinically-Oriented Antimicrobial Resistance Surveillance Network)	Project aims to develop an efficient clinically orientated AMR surveillance system, implemented alongside routine clinical care in hospitals in LMIC settings	Wellcome Trust, University of Oxford	*2020*	View View
80. AMR Surveillance in Low- and Middle-Income Settings: A Roadmap for Participation in the Global Antimicrobial Surveillance System (GLASS)	Tool aims to facilitate AMR surveillance and participation in GLASS for LMICs; outlines an approach that allows the independent development of each component of surveillance to build a comprehensive system	Fleming Fund	*2016*	View
81. Critically Important Antimicrobials for Human Medicine: 6th Revision	Publication issued by WHO Advisory Group on Integrated Surveillance of Antimicrobial Resistance (AGISAR) every two years; reviews and updates the WHO List of Critically Important Antimicrobials for Human Medicine; ranks medically important antimicrobials for risk management of antimicrobial resistance due to nonhuman use	WHO	*2019*	View
82. WHO Guide for the Stepwise Laboratory Improvement Process Towards Accreditation in the African Region	Offers practical guidance to improve laboratory services, infrastructure, and quality assurance, with a focus on the African region	WHO	*2017*	View
83. WHO Global Guidelines on the Prevention of Surgical Site Infection	Lists 29 evidence-based recommendations for patients and health systems to address health care–associated infections	WHO	*2018*	View
84. Infection Control in Healthcare Personnel: Infrastructure and Routine Practices for Occupational Infection Prevention and Control Services	Provides information and recommendations for health care professionals on preventing transmission of infectious diseases among health care personnel and patients	US CDC	*2019*	View

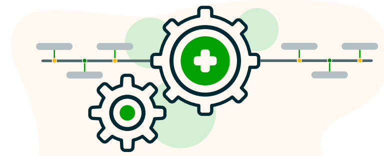
TOOL	DESCRIPTION	ORGANIZATION	YEAR ISSUED/ LAUNCHED	SOURCE
85. WHO Guidelines on Use of Medically Important Antimicrobials in Food-Producing Animals	Guidelines on use of medically important antimicrobials in food-producing animals; recommends that farmers and the food industry stop routine use of antibiotics to promote growth and prevent disease in healthy animals	WHO	*2017*	View
86. WHO Costing and Budgeting Tool for National Action Plans on Antimicrobial Resistance	Modular tool to support countries with costing and budgeting of prioritized activities in National Action Plans; allows decision-makers to identify different funding flows and budget gaps, and to use dashboards to advocate for additional resources where needed	WHO	*2021*	View
87. WHO Implementation Handbook for National Action Plans on Antimicrobial Resistance	Provides comprehensive stepwise guidance for National Action Plan implementation within the human health sector; collates and summarizes existing WHO tools and resources to support countries with readiness assessments, governance and multisectoral coordination, activity prioritization, and implementation of tools across the strategic objectives of the Global Action Plan on AMR	WHO	*2022*	View
88. FAO Situation Analysis of AMR Risks in the Food and Agriculture Sectors	Designed by the FAO Regional Office for Latin America and the Caribbean to help LMICs organize their baseline information on AMR and associated risks and gaps; allows countries to define mitigation measures with a multisectoral approach, coordinated between actors from animal health, public health, and the environment	FAO	*2021*	View
89. Tailoring Antimicrobial Resistance Programmes (TAP) Quick Guide	Provides a step-by-step, practical approach to designing and implementing targeted behavior change interventions that address drivers of AMR in human and animal health	WHO	*2021*	View

TOOL	DESCRIPTION	ORGANIZATION	YEAR ISSUED/ LAUNCHED	SOURCE
90. Tailoring Antimicrobial Resistance Programmes (TAP) Toolbox	Accompanies the TAP Quick Guide with exercises and tools to assist in each stage of project development	WHO	*2021*	View
91. Tripartite Integrated System for Surveillance of AMR/AMU (TISSA)	A global web-based repository of antimicrobial resistance and use data across human health, animal health, and food and agriculture sectors	WHO, FAO, and WOAH	*TBD*	View
92. WASH in Health Care Facilities: Global Progress Report 2020	Describes national, regional, and global progress on WASH services in health care facilities	WHO, UNICEF	*2020*	View
93. Infection Prevention and Control: Guidance to Action Tools	Outlines multimodal improvement strategies to implement IPC interventions; includes standard and transmission-based precautions according to national guidelines or standard operating procedures and under the coordination of the national IPC focal point/team	WHO	*2021*	View
94. Understanding Barriers to Quality of Care: An Approach for Conducting a Situational Analysis of Water, Sanitation and Hygiene (WASH) and Quality in Health Care Facilities	Describes an approach for conducting a national situational analysis of WASH as a basis for improving quality of care	WHO	*2021*	View
95. WHO Policy Guidance on Integrated Antimicrobial Stewardship Activities	Outlines policy guidance on how to facilitate the implementation of national AMS activities in an integrated and programmatic approach	WHO	*2021*	View
96. Antimicrobial Stewardship Interventions: A Practical Guide	Describes 10 common stewardship interventions (and evidence behind them) to promote optimal use of antimicrobials at health care facilities; describes implementation considerations, particularly for low-resource settings	WHO	*2021*	View

TOOL	DESCRIPTION	ORGANIZATION	YEAR ISSUED/ LAUNCHED	SOURCE
97. African Union Framework for Antimicrobial Resistance Control 2020–2025	Describes the African Union's priorities on AMR for the forthcoming five years; aim is to improve surveillance, delay emergence, limit transmission, and mitigate harm from antimicrobial resistance	African Union	*2020*	View
98. Joint Risk Assessment Operational Tool	Supports countries in assessing risks, including AMR, at the human–animal–environment interface	WHO, FAO, and WOAH	*2020*	View
99. Global Repository of Available Guidelines for Responsible Use of Antimicrobials In Animal Health	Based on a 2018 survey by World Veterinary Association and WOAH; lists 102 guidelines, action plans, and promotional material on prudent use of antimicrobials, covering large number of countries, languages, veterinary aspects, and animal species	World Veterinary Association, WOAH	*2019*	View
100. Strengthening Infection Prevention and Control in Primary Care: A Collection of Existing Standards, Measurement and Implementation Resources	Aims to support those working in primary care to strengthen IPC; informed by existing WHO IPC guidance and implementation resources	WHO	*2021*	View

Source: Adapted from World Bank 2021.

Table 14. Tools Organized by Project Phase


Project identification, preparation, and appraisal **PHASE 1**	Implementation **PHASE 2**	Completion and evaluation **PHASE 3**
FAO Assessment Tool for Laboratories and Surveillance Systems (FAO-ATLASS)	Global Action Plan on AMR (GAP-AMR)	Tripartite Integrated Surveillance System on AMR/AMU (TISSA)
FAO Laboratory Mapping Tool (LMT)	Strategy on AMR and the Prudent Use of Antimicrobials	Global Antimicrobial Resistance and Use Surveillance System (GLASS) and One Health module
AWaRe tool	FAO Action Plan on Antimicrobial Resistance	Country Progress on the Implementation of the Global Action Plan on Antimicrobial Resistance: WHO, FAO, and WOAH Global Tripartite Database
The AWaRe Campaign: “Adopt AWaRe. Handle Antibiotics with Care.”	Progressive Management Pathway for AMR (FAO-PMP AMR)	Industry Alliance against AMR Progress Report
Antibiotic Prescribing and Resistance: Views from Low- and Middle-Income Prescribing and Dispensing Professionals	WHO AMR Stewardship Programmes in Health-care Facilities and LMICs Toolkit	Tripartite AMR Country Self-Assessment Survey (TrACSS)
WHO Situation Analysis	AMR Framework for Action Supported by the IACG	FAOSTAT
Antimicrobial Resistance: A Manual for Developing National Action Plans	WHO Competency Framework for Health Workers’ Education and Training on Antimicrobial Resistance	The 4th Annual WOAH Report on Antimicrobial Agents Intended for Use in Animals
WHO Benchmarks for IHR Capacities	Strategic Research Agenda: Joint Programming Initiative on Antimicrobial Resistance	World Antibiotic Awareness Week 2018: Monitoring & Evaluation Report
Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS)	Technical Brief on Water, Sanitation, Hygiene (WASH) and Wastewater Management to Prevent Infections and Reduce the Spread of Antimicrobial Resistance (AMR)	Africa CDC Antimicrobial Resistance Surveillance Network (AMRSNET)
AMR Benchmark	Guidelines on Core Components of Infection Prevention and Control Programmes at the National and Acute Health Care Facility Level	FAO Surveillance Evaluation Tool
WHO Hand Hygiene Self-Assessment Framework, and the WHO Infection Prevention and Control Assessment Framework	FAO Resource Package on Good Hygiene Practices	WASH in Health Care Facilities: Global Progress Report 2020

PHASE 1: Project identification, preparation, and appraisal	PHASE 2: Implementation and supervision	PHASE 3: Completion and evaluation
WOAH PVS Pathway	FAO Good Practices for Biosecurity in the Pig Sector	Integrated Surveillance of Antimicrobial Resistance
STAR-IDAZ International Research Consortium	Antimicrobials in Agriculture and the Environment: Reducing Unnecessary Use and Waste	Monitoring and Evaluation of the Global Action Plan on Antimicrobial Resistance: Framework and Recommended Indicators
WHO Model List of Essential Medicines: 20th List	AMR National Action Plan Support Tools	
ReAct Online Toolbox for National Action Plans	ReAct Online Toolbox for National Action Plans	
WASH in Health Care Facilities: Global Baseline Report 2019	Summary Report of the FAO/WHO Expert Meeting on Foodborne Antimicrobial Resistance: Role of Environment, Crops and Biocides	
Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines	Declaration by the Pharmaceutical, Biotechnology and Diagnostics Industries on Combating Antimicrobial Resistance	
Joint External Evaluation	Tackling Antimicrobial Resistance: Ensuring Sustainable R&D	
US CDC Laboratory Assessment of AMR Testing Capacity (LAARC)	Guidelines for the Prevention and Control of Carbapenem-resistant Enterobacteriaceae, Acinetobacter baumannii and Pseudomonas aeruginosa in Health Care Facilities	
Guidelines for the Development of National Action Plan for Health Security	Global Framework for Development & Stewardship to Combat Antimicrobial Resistance: Draft Roadmap	
WHO AMR Stewardship Programmes in Healthcare Facilities and LMICs Toolkit	WASH in Health Care Facilities: Practical Steps to Achieve Universal Access to Quality Care	
Technical Brief on Water, Sanitation, Hygiene (WASH) and Wastewater Management to Prevent Infections and Reduce the Spread of Antimicrobial Resistance (AMR)	Global Research on Antimicrobial Resistance (GRAM) Project	
Guidelines for the Prevention and Control of Carbapenem-resistant Enterobacteriaceae, Acinetobacter baumannii and Pseudomonas aeruginosa in Healthcare Facilities	WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene	

PHASE 1: Project identification, preparation, and appraisal	PHASE 2: Implementation and supervision	PHASE 3: Completion and evaluation
PVS Gap Analysis Tool	WOAH Data Collection Template and Related Guidance	
International Instruments on the Use of Antimicrobials across the Human, Animal and Plant Sectors	Diagnostic Stewardship: A Guide to Implementation in Antimicrobial Resistance Surveillance Sites	
WHO Global Guidelines on the Prevention of Surgical Site Infection	ASEAN Regional Strategy on AMR Communication and Advocacy	
WHO Guidelines on Use of Medically Important Antimicrobials in Food-Producing Animals	Estimating the Economic Costs of Antimicrobial Resistance: Model and Results	
FAO Surveillance Evaluation Tool	Antibacterial Agents in Clinical Development: An Analysis of the Antibacterial Clinical Development Pipeline, Including Tuberculosis	
Monitoring and Evaluation of the Global Action Plan on Antimicrobial Resistance: Framework and Recommended Indicators	PVS Gap Analysis Tool	
WOAH Data Collection Template and Related Guidance	Resistance Map	
WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene	Health Workers' Education and Training on Antimicrobial Resistance: Curricula Guide	
Global Research on Antimicrobial Resistance (GRAM) Project	The Structured Operational Research and Training IniTiative on AMR, Coordinated by the Special Programme for Research and Training in Tropical Diseases (TDR)	
The 4th Annual WOAH Report on Antimicrobial Agents Intended for Use in Animals	Integrated Surveillance of Antimicrobial Resistance	
Resistance Map	Tackling Antimicrobial Resistance Together (Working Paper 5.0): Enhancing the Focus on Gender and Equity	
Reframing Resistance	The Environment as a Driver of Antibiotic Resistance	
Global Priority List of Antibiotic-Resistant Bacteria to Guide Research, Discovery, and Development of New Antibiotics	Frontiers 2017: Emerging Issues of Environmental Concern	

PHASE 1: Project identification, preparation, and appraisal	PHASE 2: Implementation and supervision	PHASE 3: Completion and evaluation
Preventing the Next Pandemic: Zoonotic Diseases and How to Break the Chain of Transmission	Preventing the Next Pandemic: Zoonotic Diseases and How to Break the Chain of Transmission	
Frontiers 2017: Emerging Issues of Environmental Concern	Reframing Resistance	
FAO Methodology to Analyze AMR-relevant legislation in the food and agriculture sectors	Gulf–Middle East–North Africa Antimicrobial Stewardship Network	
FAOLEX	Tackling Antimicrobial Resistance Together (Working Paper 1.0): Multisectoral Coordination	
African Union Framework for Antimicrobial Resistance Control 2020–2025	An Analysis of the Animal/Human Interface with a Focus on Low- and Middle-Income Countries	
Tailoring Antimicrobial Resistance Programmes (TAP) Toolbox	The Industry Roadmap for Progress on Combating Antimicrobial Resistance	
WASH in Health Care Facilities: Global Progress Report 2020	Core Elements of Human Antibiotic Stewardship Programs in Resource-Limited Settings	
Understanding Barriers to Quality of Care: An Approach for Conducting a Situational Analysis of Water, Sanitation and Hygiene (WASH) and Quality in Health Care Facilities	International Instruments on the Use of Antimicrobials across the Human, Animal and Plant Sectors	
Global Priority List of Antibiotic-Resistant Bacteria to Guide Research, Discovery, and Development of New Antibiotics	ACORN (Clinically-Oriented Antimicrobial Resistance Surveillance Network)	
WHO Situation Analysis	Time Is Running Out Technical Note	
Health Workers' Education and Training on Antimicrobial Resistance: Curricula Guide	AMR Surveillance in Low- and Middle-Income Settings: A Roadmap for Participation in the Global Antimicrobial Surveillance System (GLASS)	
Estimating the Economic Costs of Antimicrobial Resistance: Model and Results	WHO Policy Guidance on Integrated Antimicrobial Stewardship Activities	
Critically Important Antimicrobials for Human Medicine: 5th Revision	Infection Prevention and Control: Guidance to Action Tools	

PHASE 1: Project identification, preparation, and appraisal	PHASE 2: Implementation and supervision	PHASE 3: Completion and evaluation
Critically Important Antimicrobials for Human Medicine: 5th Revision	WHO Guide for the Stepwise Laboratory Improvement Process Towards Accreditation in the African Region	
Joint Risk Assessment Operational Tool	WHO Global Guidelines on the Prevention of Surgical Site Infection	
WHO Policy Guidance on Integrated Antimicrobial Stewardship Activities	Infection Control in Healthcare Personnel: Infrastructure and Routine Practices for Occupational Infection Prevention and Control Services	
Library of National Action Plans	WHO Guidelines on Use of Medically Important Antimicrobials in Food-Producing Animals	
WHO Global Guidelines on the Prevention of Surgical Site Infection	WHO Costing and Budgeting Tool for National Action Plans on Antimicrobial Resistance	
WHO Guidelines on Use of Medically Important Antimicrobials in Food-Producing Animals	Draft WHO Implementation Handbook for National Action Plans on Antimicrobial Resistance	
Global Repository of Available Guidelines for Responsible Use of Antimicrobials in Animal Health	Draft FAO Situation Analysis of AMR Risks in the Food and Agriculture Sectors	
	Antimicrobial Stewardship Interventions: A Practical Guide	
	Tailoring Antimicrobial Resistance Programmes (TAP) Quick Guide	
	Strengthening Infection Prevention and Control in Primary Care: A Collection of Existing Standards, Measurement and Implementation Resources	

Source: World Bank compilation.

Costing and implementing AMR interventions, including NAPs

The JEEs and the TrACSS data have shown that costing and securing financing are widespread challenges in addressing AMR in LMICs. National Actions Plans translate the WHO's Global Action Plan on AMR into local priorities. As of 2020, TrACSS found that only 20 percent of NAPs were fully funded and 40 percent had a budgeted operational plan (WHO 2021c). Successive JEE reports have also highlighted a gap in financing for health security and AMR. This section focuses on costing tools for AMR interventions, including NAPs.

Donors and development partners have key roles in facilitating action on AMR and supporting activities that are excluded from government plans and budgets. However, country case studies undertaken by WHO on NAP implementation show the difficulty of identifying sources of donor support, and note the lack of tools that could help LMICs find and access financial and technical support from donors. In these circumstances, a well-designed and costed NAP is a useful tool for raising awareness, coordinating across stakeholders and sectors, fostering ownership, promoting accountability, and monitoring and evaluating actions on AMR in the country. Costed NAPs are decision tools that allow countries to identify the activities that are easiest to scale up, most cost-effective, or potentially able to provide the greatest impact; this information in turn enables governments to prioritize activities and allocate resources effectively and efficiently. Costed NAPs can also enable stakeholders to pinpoint resource gaps as well as existing or potential bottlenecks and optimize alignment with other policy processes and priorities.

Increasingly, costing tools are being developed to identify and allocate the resources required to build and sustainably implement NAPs for AMR. There has previously been a limited evidence base for countries wishing to select and implement appropriate costing strategies, particularly for AMR. Currently, the inventory of costing tools relevant to AMR actions can be categorized as follows: (i) tools that target AMR-specific activities that are new or focused on antimicrobial resistance only; (ii) tools that target AMR-sensitive activities that are contained within existing programs; and (iii) tools that target AMR activities linked to the wider health system. Building on costing approaches for implementation of the IHR, two broad methodologies (detailed or action-based) have been outlined for strategic costing of capacity assessment processes, such as the JEE, to prevent, detect, and respond to AMR and other public health threats (Mghamba et al. 2018). NAP costing refers to the process of assigning cost to each activity in the plan. Costing is the first step toward developing a NAP budget and should be accompanied by identifying the relevant sources of funding for each activity. NAP costing strategies can be either detailed (i.e., can aggregate the individual components of country-defined activities to generate an overall cost estimate) or action-based (i.e., estimate costs for a set of predefined actions based on country capacity levels). The following AMR-relevant costing tools have been developed for the purposes of costing and resource planning.

The WHO (2021c) NAP Costing and Budgeting Tool is a modular tool to support countries with the costing and budgeting of prioritized activities included in their NAPs, and it is relevant for AMR-specific activities. It allows users to identify funding flows and budget gaps and to use dashboards to advocate for additional resources, where needed. Accompanied by a user guide, a training package, and a web-based help desk, the tool is designed to support multisectoral participation and collaboration. It has been piloted in Africa (Sierra Leone and Somalia) and Latin America and the Caribbean (Jamaica and Paraguay) and is being rolled out more widely.

The WHO (2021a) NAP Costing and Budgeting Tool, the Costing Tool for IHR, and the Priority Actions Costing Tool can target AMR-sensitive activities that are contained within existing programs. The National Action Plan for Health Security (NAPHS) is a process developed by WHO to create capacity-building plans based on recommendations from the International Health Regulations Monitoring and Evaluation Framework,[48] country risk assessments, and other assessments. The NAPHS includes activities that are developed to address gaps identified by the IHR Monitoring and Evaluation Framework, as well as activities from other national plans, including those for antimicrobial resistance and influenza pandemic preparedness. The output of the NAPHS process includes a cost envelope of the actions required to increase preparedness for health emergencies, which can be used to develop specific annual implementation plans, allocate domestic budgets, and mobilize resources from bilateral and multilateral partners (Katz et al. 2012).

The Costing Tool for IHR implementation (Global Health Security Index 2019) was developed in collaboration between WHO and the George Washington, Emory, and Australian National Universities, and is organized by IHR Core Capacities and public health core functions. Estimated costs are calculated using a template to identify inputs—for example, personnel compensation, travel and per diem, meeting costs—that can be systematically applied to appropriate public health actions necessary to fulfill each IHR attribute with appropriate multipliers such as the number of districts. The Priority Actions Costing Tool (PACT) (Lee et al. 2020) was developed by the US Centers for Disease Control and Prevention and is designed to quickly generate cost estimates for priority actions outlined from a country's JEE report. Priority actions consist of three to four recommendations provided by the external assessment team for each technical area and are based on the strengths and weaknesses identified through the JEE process. The tool is based on key actions required for the attainment of improved JEE scores.

The Avenir OneHealth Tool is an example of a tool that targets AMR activities linked to the wider health system.[49] The OneHealth Tool links strategic objectives and targets of disease control and prevention programs to outlined investments in health systems. It provides planners with a single framework for scenario analysis, costing, health impact analysis, budgeting, and financing of strategies for all major diseases and health system components. It is primarily intended to inform sector-wide national strategic health plans and policies. WHO provides technical oversight to the development of the tool, facilitates capacity building, and provides technical support to policy makers to inform national planning and resource needs estimates. The first official version of the OneHealth Tool was released in May 2012. The tool has since been applied in over 55 countries, mostly in Sub-Saharan Africa.

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48 World Health Organization, "IHR Monitoring and Evaluation Framework," https://extranet.who.int/sph/ihr-monitoring-evaluation.

49 See Avenir Health, "OneHealth Tool," https://www.avenirhealth.org/software-onehealth.php; World Health Organization, "One Health Tool," https://www.who.int/tools/onehealth.

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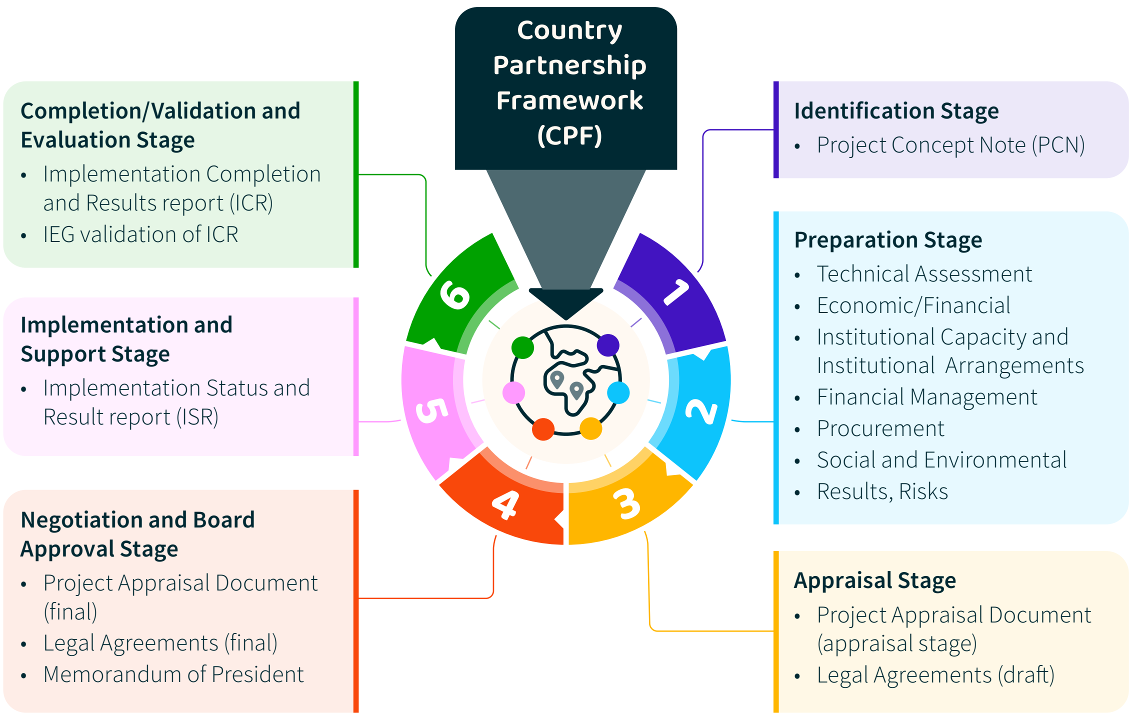
Appendices

Appendix 1
An Overview of the World Bank Project Cycle and Instruments

The World Bank provides financing and services to low- and middle-income countries to support development and change, including the development of health, agriculture, and water and sanitation systems. Development projects are implemented by borrowing countries following certain rules and procedures to guarantee that the money reaches its intended target. The project cycle is the framework used to design, prepare, implement, and supervise projects. The duration of the project cycle is long by commercial standards. It is not uncommon for a project to last more than four years from the time it is identified until the time it is completed. A World Bank project consists of six stages: Identification, Preparation, Appraisal, Negotiation/Approval, Implementation/Support, and Completion/Evaluation (as shown in Figure 3).

Figure 3. The World Bank Project Cycle



Source: World Bank, "The World Bank Project Cycle," https://www.worldbank.org/en/projects-operations/products-and-services/brief/projectcycle.

Note: IEG = Independent Evaluation Group; PAD = Project Appraisal Document.

In the Identification stage, the World Bank works with a borrowing country's government and other stakeholders to determine how financial and other assistance can be designed to have the largest impact. After analytical work is conducted, the borrower and the World Bank Group produce a strategy, called the Country Partnership Framework, to identify the country's highest priorities for reducing poverty and improving living standards.

Identified projects can range across the economic and social spectrum, from infrastructure, to education or health, to government financial management. The World Bank and the government agree on an initial project concept and its beneficiaries, and the World Bank's project team outlines the basic elements in a Project Concept Note. This document identifies proposed objectives, imminent risks, alternative scenarios, and a likely timetable for the project approval process. Two other World Bank documents are generated during this phase. The Project Information Document outlines the scope of the intended project and contains useful public information for tailoring bidding documents to the proposed project, and the publicly available Integrated Safeguards Data Sheet identifies key issues related to the World Bank's safeguard policies for environmental and social issues.

In the Project Preparation stage, the borrower government and its implementing agency or agencies are responsible for preparing the project. It can take several years to conduct feasibility studies and prepare engineering and technical designs, to name only a few of the work products required. The government contracts with consultants and other public sector companies for goods, works, and services, if necessary, not only during this phase but also later in the project's implementation phase. Beneficiaries and stakeholders are also consulted now to obtain their feedback and ensure the project meets their needs. Given the time, effort, and resources involved, the government's full commitment to the project is vital.

During the preparation phase, the World Bank generally takes an advisory role and offers analysis and advice when requested. However, it does assess the relevant capacity of the implementing agencies at this point in order to reach agreement with the borrower about arrangements for overall project management, such as the systems required for financial management, procurement, reporting, and monitoring and evaluation.

Earlier screening by World Bank staff may have determined that a proposed project could have environmental or social impacts that are included under the World Bank's Safeguard Policies. If necessary, the borrower now prepares an Environmental Assessment Report that analyzes the planned project's likely environmental impact and describes steps to mitigate possible harm. In the event of major environmental issues in a country, the borrower's Environmental Action Plan describes the problems, identifies the main causes, and formulates policies and concrete actions to deal with them. To understand a project's potentially adverse social impacts, various studies may be undertaken to analyze its effects on the health, productive resources, economies, and cultures of indigenous peoples. An Indigenous Peoples Plan identifies the borrower's planned interventions in indigenous areas with the objective of avoiding or lessening potential negative impacts on the people. These plans are integrated into the design of the project.

Projects supported through the Investment Project Financing instrument are governed by operational policies and procedures designed to ensure that the projects are economically, financially, socially, and environmentally sound. The World Bank Environmental and Social Framework (ESF), approved by the World Bank Board on August 4, 2016, expands protections for people and environments in World Bank–financed projects. The new requirements took effect in 2018 and apply to new investment projects for which a concept note is issued.

The Project Appraisal stage gives stakeholders an opportunity to review the project design in detail and resolve any outstanding questions. The government and the World Bank review the work done during the Identification and Preparation phases and confirm the expected project outcomes, intended beneficiaries, and evaluation tools for monitoring progress. Agreement is reached on the viability of all aspects of the project at this time. The World Bank team confirms that all aspects of the project are consistent with the requirements of all World Bank operations and that the government has institutional arrangements in place to implement the project efficiently. All parties agree on a project timetable and on public disclosure of key documents, and they identify any unfinished business that must be addressed for final World Bank approval. The final steps are assessment of the project's readiness for implementation and agreement on conditions for effectiveness (actions agreed upon prior to implementation). The Project Information Document is updated and released when the project is approved for funding.

Project Approval takes place once all project details are negotiated and accepted by the government and the World Bank: the project team prepares the Project Appraisal Document (for Investment Project Financing) or the Program Document (for Development Policy Financing), along with other financial and legal documents, for submission to the World Bank's Board of Executive Directors for consideration and approval. When funding approval is obtained, conditions for effectiveness are met, and the legal documents are accepted and signed, the implementation phase begins.

Project Implementation takes place when the borrower government implements the development project with funds from the World Bank. With technical assistance and support from the World Bank's team, the implementing government agency prepares the specifications for the project and carries out all procurement of goods, works, and services needed, as well as any environmental and social impact mitigation set out in agreed-upon plans. Financial management and procurement specialists on the World Bank's project team ensure that adequate fiduciary controls on the use of project funds are in place. At this phase all components are ready, but project delays and unexpected events can sometimes prompt the restructuring of project objectives.

Once underway, the implementing government agency reports regularly on project activities. The government and the World Bank also join forces twice a year to prepare the Implementation Status and Results Report, which is a review of project progress. The project's progress, outcomes, and impact on beneficiaries are monitored by the government and the World Bank throughout the implementation phase to obtain data used to evaluate and measure the ultimate effectiveness of the operation and the project's results.

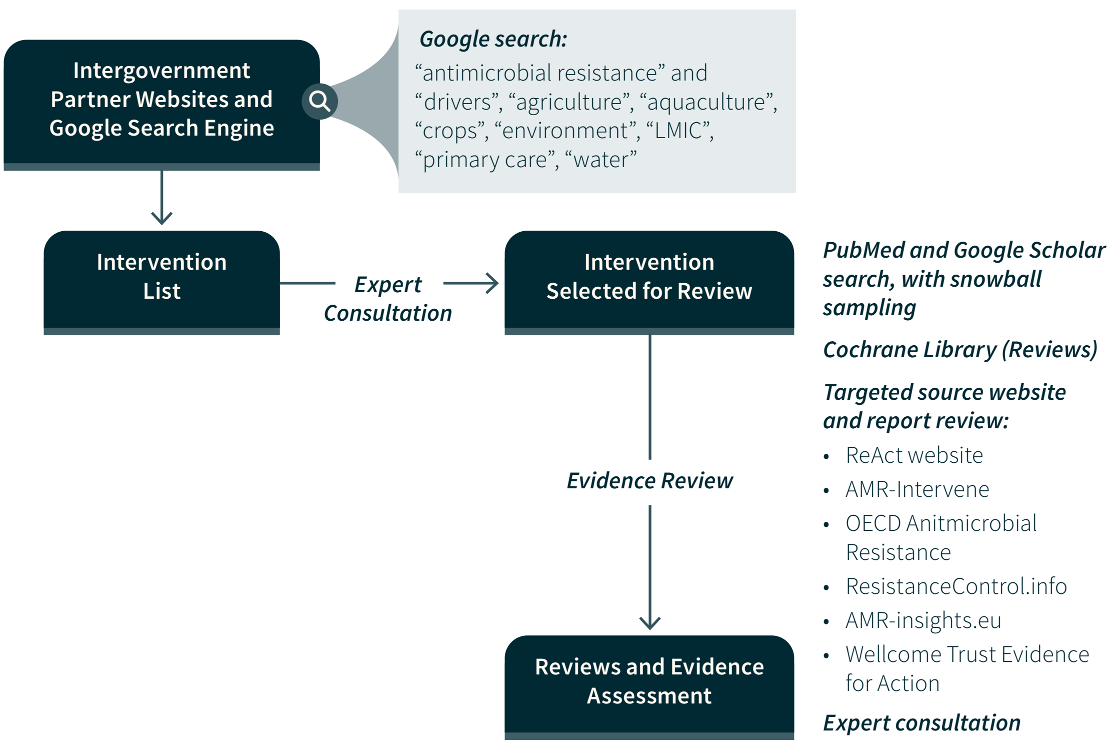
Project Completion refers to the stage when a project is completed and closed at the end of the loan disbursement period, a process that can take anywhere from 1 to 10 years. At this point the World Bank and the borrower government document the results achieved, the problems encountered, the lessons learned, and the knowledge gained in carrying out the project. A World Bank operations team compiles this information and data in an Implementation Completion and Results Report, using input from the implementing government agency, co-financiers, and other partners/stakeholders. The report describes and evaluates final project outcomes. The final outcomes are then compared to expected results. The information gained during this exercise is also often used to determine what additional government measures and capacity improvements are needed to sustain the benefits derived from the project. The evaluation team also assesses how well the entire operation complied with the World Bank's operations policies and accounts for the use of World Bank resources. The knowledge gained from this results measurement process is intended to benefit similar projects in the future.

Evaluation may be carried out by the Independent Evaluation Group (IEG), which assesses the performance of roughly one project out of four (about 70 projects a year). Evaluations measure outcomes against the original objectives, sustainability of results, and institutional development impact. From time to time, IEG also produces Impact Evaluation Reports to assess the economic worth of projects and the long-term effects on people and the environment against an explicit counterfactual. All project and bidding documents are made available to public.

Appendix 2
Methodology for the Evidence Review of Interventions

To identify potential interventions and assess the weight of the evidence for possible antimicrobial resistance (AMR) investment priorities, a literature review was conducted in two stages (Figure 4). First, a list of multisectoral interventions was developed (see Table 17); second, 20 interventions were selected for evidence review. The review was primarily web-based, relying on searches of websites and scholarly literature, and it was informed by several stages of expert consultation.

Figure 4. Overview of Methodology



Source: World Bank.

A comprehensive list of interventions with the potential to address AMR in low- and middle-income countries (LMICs) was developed across health, water, agriculture, and the environment. As shown in Table 15, the basis for the selection of interventions was AMR "drivers," which provide a practical starting point for identifying major causal pathways or conditions creating AMR risk and impact. While broad and sometimes co-occurring, drivers provide a basis for identifying more proximal and specific issues shaping outcomes and informing plausible interventions. Global-level reports and scientific papers on AMR were reviewed from partner websites and Google search engines to determine relevant drivers, key issues and context factors, and potential interventions (see Table 15 for key sources reviewed). This approach ensured that the selection of potential interventions took stock of existing knowledge, calls for action, and terminology. While the literature review was grouped by sector-specific entry points, it provided an overall understanding and identification of shared issues and interventions across sectors. This result was used to compile a list presented by (i) drivers, (ii) issues, (iii) plausible interventions (sensitive and specific), and (iv) context. As interventions are aligned to drivers, some interventions were listed multiple times. The primary sector of relevance was identified. The list was distilled down to 20 intervention areas for in-depth literature review and consultations with World Bank experts and external organizations.

Table 15. Key Background Literature for Intervention List, by Drivers, Issues, Context, and Possible Interventions

DRIVERS	PRIMARY SECTOR[a]	ISSUES, CONTEXT, AND INTERVENTIONS
Interagency Coordinating Group on Antimicrobial Resistance. 2019. “No Time to Wait.” https://www.who.int/docs/default-source/documents/no-time-to-wait-securing-the-future-from-drug-resistant-infections-en.pdf?sfvrsn=5b424d7_6. Iskandar, K., L. Molinier, S. Hallit, M. Sartelli, F. Catena, F. Coccolini, T. C. Hardcastle, C. Roques, and P. Salameh. 2020. “Drivers of Antibiotic Resistance Transmission in Low- and Middle-Income Countries from a ‘One Health’ Perspective: A Review.” Antibiotics (Basel) 9 (7): 372. doi:10.3390/antibiotics9070372. Holmes, A. H., L. S. Moore, A. Sundsfjord, M. Steinbakk, S. Regmi, A. Karkey, P. J. Guerin, and L. J. Piddock. 2016. “Understanding the Mechanisms and Drivers of Antimicrobial Resistance.” Lancet 387 (10014): 176–87. doi: 10.1016/S0140-6736(15)00473-0. Laxminarayan, R., A. Duse, C. Wattal, A. K. Zaidi, H. F. Wertheim, N. Sumpradit, E. Vlieghe, et al. 2013. “Antibiotic Resistance: The Need for Global Solutions.” Lancet Infectious Diseases 13 (12): 1057–98. doi: 10.1016/S1473-3099(13)70318-9.	**WASH and environment**	UNEP (United Nations Environment Programme). 2017. “Frontiers 2017: Emerging Issues of Environmental Concern.” UNEP, Nairobi. https://www.unep.org/resources/frontiers-2017-emerging-issues-environmental-concern. WHO (World Health Organization), FAO (Food and Agriculture Organization of the United Nations), and WOAH (World Organisation for Animal Health). 2020. “Technical Brief on Water, Sanitation, Hygiene and Wastewater Management to Prevent Infections and Reduce the Spread of Antimicrobial Resistance.” https://www.who.int/publications/i/item/9789240006416. Wellcome Trust. 2018. “Initiatives for Addressing Antimicrobial Resistance in the Environment: Current Situation and Challenges.” https://wellcome.ac.uk/sites/default/files/antimicrobial-resistance-environment-report.pdf. Hendriksen, R. S., P. Munk, P. Njage, B. van Bunnik, L. McNally, O. Lukjancenko, and T. Röder, et al. 2019. “Global Monitoring of Antimicrobial Resistance Based on Metagenomics Analyses of Urban Sewage.” 2019. Nature Communications 10: 1124. https://doi.org/10.1038/s41467-019-08853-3. Fouz, N., K. N. A. Pangesti, M. Yasir, A. L. Al-Malki, E. I. Azhar, G. A. Hill-Cawthorne, and M. A. El Ghany. 2020. “The Contribution of Wastewater to the Transmission of Antimicrobial Resistance in the Environment: Implications of Mass Gathering Settings.” Tropical Medicine and Infectious Disease 5 (1): 33. doi: 10.3390/tropicalmed5010033.

DRIVERS	PRIMARY SECTOR[a]	ISSUES, CONTEXT, AND INTERVENTIONS
	Agriculture and food safety	WOAH (World Organisation for Animal Health). 2020. WOAH Standards, Guidelines and Resolutions on Antimicrobial Resistance and the Use of Antimicrobial Agents. Paris: WOAH. https://www.WOAH.org/app/uploads/2021/03/book-amr-ang-fnl-lr.pdf. FAO (Food and Agriculture Organization of the United Nations). 2020. "Understanding Antimicrobial Resistance in Aquaculture." Asian Fisheries Society. http://www.fao.org/documents/card/en/c/cb2601en. FAO (Food and Agriculture Organization) and WHO (World Health Organization). 2021a. "Code of Practice to Minimize and Contain Foodborne Antimicrobial Resistance." CXC 61-2005. Adopted 2005; revised 2021. Codex Alimentarius Commission. CXC_061e.pdf (directoriolegislativo.org). FAO (Food and Agriculture Organization) and WHO (World Health Organization). 2011. "Guidelines for Risk Analysis of Foodborne Antimicrobial Resistance." Cac/Gl 77-2011. Adopted 2011. Codex Alimentarius Commission. http://www.fao.org/fao-who-codexalimentarius/thematic-areas/antimicrobial-resistance/en/. Van Boeckel, Thomas P., João Pires, Reshma Silvester, Cheng Zhao, Julia Song, Nicola G. Criscuolo, Marius Gilbert, Sebastian Bonhoeffer, and Ramanan Laxminarayan. 2019. "Global Trends in Antimicrobial Resistance in Animals in Low- and Middle-Income Countries." Science 365 (6459): eaaw1944. https://doi.org/10.1126/science.aaw1944. Schar, D., E. Y. Klein, R. Laxminarayan, Marius Gilbert, and Thomas P. Van Boeckel. 2020. "Global Trends in Antimicrobial Use in Aquaculture." Scientific Reports 10: 21878. https://doi.org/10.1038/s41598-020-78849-3. Taylor, P., and R. Reeder. 2020. "Antibiotic Use on Crops in Low and Middle-Income Countries Based on Recommendations Made by Agricultural Advisors." CABI Agriculture and Bioscience 1 (1). https://doi.org/10.1186/s43170-020-00001-y. Marshall B. M., and S. B. Levy. 2011. "Food Animals and Antimicrobials: Impacts on Human Health." Clinical Microbiology Reviews 24 (4): 718–33. doi: 10.1128/CMR.00002-11.

DRIVERS	PRIMARY SECTOR[a]	ISSUES, CONTEXT, AND INTERVENTIONS
	Health	WHO (World Health Organization). 2015. "Global Action Plan on Antimicrobial Resistance." WHO, Geneva. https://apps.who.int/iris/bitstream/handle/10665/193736/9789241509763_eng.pdf?sequence=1. WHO (World Health Organization). 2015. "Worldwide Country Situation Analysis: Response to Antimicrobial Resistance." https://iris.who.int/bitstream/handle/10665/163468/9789241564946_eng.pdf;sequence=1. https://apps.who.int/iris/bitstream/handle/10665/163468/9789241564946_eng.pdf;sequence=1. WHO (World Health Organization). 2018. "Antimicrobial Resistance and Primary Health Care. https://www.who.int/docs/default-source/primary-health-care-conference/amr.pdf?sfvrsn=8817d5ba_2. WHO (World Health Organization). 2019. Antimicrobial Stewardship Programs in Health-Care Facilities in Low- and Middle-Income Countries. A WHO Practical Toolkit. Geneva: WHO. https://apps.who.int/iris/handle/10665/329404. UNICEF. 2019. "Time Is Running Out: Technical Note on Antimicrobial Resistance." https://www.unicef.org/documents/amr-urgent-threat-drug-resistant-infections. Sartelli, M., C. Hardcastle, F. Catena, A. Chichom-Mefire, F. Coccolini, S. Dhingra, M. Haque, et al. 2020. "Antibiotic Use in Low and Middle-Income Countries and the Challenges of Antimicrobial Resistance in Surgery." Antibiotics (Basel) 9 (8): 497. doi:10.3390/antibiotics9080497.

Source: World Bank compilation.

a. *Some sources informed issues, context, and intervention in multiple sectors. WASH = water, sanitation, and hygiene.*

Drawing on existing reviews where available, a high-level summary of the evidence base was developed for 20 interventions to provide an indication of the state of knowledge. For this stage, the team utilized a broad search strategy on PubMed for quick screening of titles of topical relevance and for full-text review of all results (see Table 16). In select cases, Google Scholar was also used to broaden the search; these results were sorted by relevance, and only the first 250 results were reviewed for feasibility. While targeted searches were conducted for each intervention or group of interventions, relevant evidence found incidentally for another intervention was included. The Cochrane Library was also searched (title abstract keyword, Reviews only). Titles and abstracts were scanned for relevance. The primary review of literature was conducted in May and June 2021, unless otherwise specified. Preference was given to evidence generated in the past 10 years to best reflect current AMR challenges and knowledge. Literature was reviewed in English. Snowball sampling from reviewed papers provided a source of additional programs and references, as did grey literature obtained through key websites reporting on interventions and evidence (e.g., ReAct and the AMResilience Intervene database). While reports on dedicated interventions were the focus, cross-sectional studies and topic reviews provided crucial background that broadly illuminated scope, types of impacts to beexpected, feasibility, and gaps.

For each intervention, the review reported on intervention scope; the state of knowledge and indications of effectiveness, with country case studies; feasibility considerations; gaps in knowledge; and key takeaways. Given the range of implementation approaches, metrics, sample sizes, and formats (e.g., systematic reviews, grey literature), meta-analysis was not conducted. Intervention evidence criteria were selected and an assessment was conducted to group intervention areas by likelihood of success for investments.

Consultations with World Bank staff and external experts were held as part of iterative evidence gathering, analysis, and prioritization of interventions. This outreach sought to validate findings and assumptions and identify any gaps in intervention scope as well as available evidence, particularly for unpublished and negative findings.

Search terms

Table 16. Search Strategy for Intervention Reviews

Health sector

TOPIC	SEARCH TERM	RESULT	RESULTS
1 Improving infection prevention and control in health care settings			
Improving infection prevention and control	("infection prevention and control" OR "IPC") AND ("intervention" OR "pilot" OR "upgrade" OR "improve" OR "facility" OR "community") AND ("antibiotic resistance" OR "antimicrobial resistance" OR "antibiotic use")	PubMed	503
2 Improving prescribing practices through guidelines for health care workers			
Prescribing guidelines	"stewardship" AND "rational prescribing " AND (antibiotic resistance OR antimicrobial resistance) AND (LMICs OR LMIC OR "low-and-middle income " OR "Africa" OR Asia OR Afghanistan OR Albania OR Algeria OR Angola OR "Antigua and Barbuda" OR Argentina OR Armenia OR Azerbaijan OR Bangladesh OR Belarus OR Belize OR Benin OR Bhutan OR Bolivia OR "Bosnia and Herzegovina" OR Botswana OR Brazil OR "Burkina Faso" OR Burundi OR "Cabo Verde" OR Cambodia OR Cameroon OR "Central African Republic" OR Chad OR China OR Colombia OR Comoros OR "Democratic Republic of Congo" OR Congo OR "Cook Islands" OR "Costa Rica" OR "Côte d'Ivoire" OR Cuba OR Djibouti OR Dominica OR "Dominican Republic" OR Ecuador OR Egypt OR "El Salvador" OR "Equatorial Guinea" OR Eritrea OR Ethiopia OR Fiji OR Gabon OR Gambia OR Georgia OR Ghana OR Grenada OR Guatemala OR Guinea OR "Guinea-Bissau" OR Guyana OR Haiti OR Honduras OR India OR Indonesia OR Iran OR Iraq OR Jamaica OR Jordan OR Kazakhstan OR Kenya OR Kiribati OR "Democratic People's Republic of Korea" OR Kosovo OR Kyrgyzstan OR Lao People's Democratic Republic OR Lebanon OR Lesotho OR Liberia OR Libya OR "Former Yugoslav Republic of Macedonia" OR Madagascar OR Malawi OR Malaysia OR Maldives OR Mali OR "Marshall Islands" OR Mauritania OR Mauritius OR Mexico OR Micronesia OR Moldova OR Mongolia OR Montenegro OR Montserrat OR Morocco OR Mozambique OR Myanmar OR Namibia OR Nauru OR Nepal OR Nicaragua OR Niger OR Nigeria OR Niue OR Pakistan OR Palau OR Panama OR Paraguay OR Peru OR Philippines OR Rwanda OR "Saint Helena" OR Samoa OR "São Tomé and Príncipe" OR Senegal OR Serbia OR Sierra Leone OR "Solomon Islands" OR Somalia OR "South Africa" OR "South Sudan" OR "Sri Lanka" OR "Saint Lucia" OR "Saint Vincent and the Grenadines" OR Sudan OR Suriname OR Swaziland OR "Syrian Arab Republic" OR Tajikistan OR Tanzania OR Thailand OR "Timor-Leste" OR Togo OR Tokelau OR Tonga OR Tunisia OR Turkey OR Turkmenistan OR Tuvalu OR Uganda OR Ukraine OR Uzbekistan OR Vanuatu OR Venezuela OR Vietnam OR "Wallis and Futuna" OR "West Bank and Gaza Strip" OR Yemen OR Zambia OR Zimbabwe)	PubMed	1,113

TOPIC	SEARCH TERM	RESULT	RESULTS
3 Conducting public awareness campaigns			
Public awareness campaign/ intervention	"public awareness" OR "awareness" AND "antimicrobial resistance" AND (LMICs OR LMIC OR "low-and-middle income " OR "Africa" OR Asia OR Afghanistan OR Albania OR Algeria OR Angola OR "Antigua and Barbuda" OR Argentina OR Armenia OR Azerbaijan OR Bangladesh OR Belarus OR Belize OR Benin OR Bhutan OR Bolivia OR "Bosnia and Herzegovina" OR Botswana OR Brazil OR "Burkina Faso" OR Burundi OR "Cabo Verde" OR Cambodia OR Cameroon OR "Central African Republic" OR Chad OR China OR Colombia OR Comoros OR "Democratic Republic of Congo" OR Congo OR "Cook Islands" OR "Costa Rica" OR "Côte d'Ivoire" OR Cuba OR Djibouti OR Dominica OR "Dominican Republic" OR Ecuador OR Egypt OR "El Salvador" OR "Equatorial Guinea" OR Eritrea OR Ethiopia OR Fiji OR Gabon OR Gambia OR Georgia OR Ghana OR Grenada OR Guatemala OR Guinea OR "Guinea-Bissau" OR Guyana OR Haiti OR Honduras OR India OR Indonesia OR Iran OR Iraq OR Jamaica OR Jordan OR Kazakhstan OR Kenya OR Kiribati OR "Democratic People's Republic of Korea" OR Kosovo OR Kyrgyzstan OR Lao People's Democratic Republic OR Lebanon OR Lesotho OR Liberia OR Libya OR "Former Yugoslav Republic of Macedonia" OR Madagascar OR Malawi OR Malaysia OR Maldives OR Mali OR "Marshall Islands" OR Mauritania OR Mauritius OR Mexico OR Micronesia OR Moldova OR Mongolia OR Montenegro OR Montserrat OR Morocco OR Mozambique OR Myanmar OR Namibia OR Nauru OR Nepal OR Nicaragua OR Niger OR Nigeria OR Niue OR Pakistan OR Palau OR Panama OR Paraguay OR Peru OR Philippines OR Rwanda OR "Saint Helena" OR Samoa OR "São Tomé and Príncipe" OR Senegal OR Serbia OR Sierra Leone OR "Solomon Islands" OR Somalia OR "South Africa" OR "South Sudan" OR "Sri Lanka" OR "Saint Lucia" OR "Saint Vincent and the Grenadines" OR Sudan OR Suriname OR Swaziland OR "Syrian Arab Republic" OR Tajikistan OR Tanzania OR Thailand OR "Timor-Leste" OR Togo OR Tokelau OR Tonga OR Tunisia OR Turkey OR Turkmenistan OR Tuvalu OR Uganda OR Ukraine OR Uzbekistan OR Vanuatu OR Venezuela OR Vietnam OR "Wallis and Futuna" OR "West Bank and Gaza Strip" OR Yemen OR Zambia OR Zimbabwe)	PubMed	225
4 Increasing human health laboratory capacity and access to diagnostics			
Laboratory capacity	"rapid diagnosis" OR "laboratory capacity" AND "antimicrobial resistance" AND (LMICs OR LMIC OR "low-and-middle income " OR "Africa" OR Asia OR Afghanistan OR Albania OR Algeria OR Angola OR "Antigua and Barbuda" OR Argentina OR Armenia OR Azerbaijan OR Bangladesh OR Belarus OR Belize OR Benin OR Bhutan OR Bolivia OR "Bosnia and Herzegovina" OR Botswana OR Brazil OR "Burkina Faso" OR Burundi OR "Cabo Verde" OR Cambodia OR Cameroon OR "Central African Republic" OR Chad OR China OR Colombia OR Comoros OR "Democratic Republic of Congo" OR	PubMed	273

TOPIC	SEARCH TERM	RESULT	RESULTS
	OR Congo OR “Cook Islands” OR “Costa Rica” OR “Côte d’Ivoire” OR Cuba OR Djibouti OR Dominica OR “Dominican Republic” OR Ecuador OR Egypt OR “El Salvador” OR “Equatorial Guinea” OR Eritrea OR Ethiopia OR Fiji OR Gabon OR Gambia OR Georgia OR Ghana OR Grenada OR Guatemala OR Guinea OR “Guinea-Bissau” OR Guyana OR Haiti OR Honduras OR India OR Indonesia OR Iran OR Iraq OR Jamaica OR Jordan OR Kazakhstan OR Kenya OR Kiribati OR “Democratic People’s Republic of Korea” OR Kosovo OR Kyrgyzstan OR Lao People’s Democratic Republic OR Lebanon OR Lesotho OR Liberia OR Libya OR “Former Yugoslav Republic of Macedonia” OR Madagascar OR Malawi OR Malaysia OR Maldives OR Mali OR “Marshall Islands” OR Mauritania OR Mauritius OR Mexico OR Micronesia OR Moldova OR Mongolia OR Montenegro OR Montserrat OR Morocco OR Mozambique OR Myanmar OR Namibia OR Nauru OR Nepal OR Nicaragua OR Niger OR Nigeria OR Niue OR Pakistan OR Palau OR Panama OR Paraguay OR Peru OR Philippines OR Rwanda OR “Saint Helena” OR Samoa OR “São Tomé and Príncipe” OR Senegal OR Serbia OR Sierra Leone OR “Solomon Islands” OR Somalia OR “South Africa” OR “South Sudan” OR “Sri Lanka” OR “Saint Lucia” OR “Saint Vincent and the Grenadines” OR Sudan OR Suriname OR Swaziland OR “Syrian Arab Republic” OR Tajikistan OR Tanzania OR Thailand OR “Timor-Leste” OR Togo OR Tokelau OR Tonga OR Tunisia OR Turkey OR Turkmenistan OR Tuvalu OR Uganda OR Ukraine OR Uzbekistan OR Vanuatu OR Venezuela OR Vietnam OR “Wallis and Futuna” OR “West Bank and Gaza Strip” OR Yemen OR Zambia OR Zimbabwe)		
Rapid diagnostics [Conducted for papers published through 2022]	(“rapid diagnostic” OR “rapid test” OR “point of care” OR “point-of-care” OR “bedside” OR “near-patient”) AND (“access” OR “availability”) AND (“antimicrobial resistance” OR “AMR” OR “antimicrobial use” OR “antibiotic use” OR “antibiotic prescribing”)	PubMed	107
5 Strengthening surveillance of antimicrobial use (AMU) and AMR in human populations			
Surveillance	“surveillance” AND (antibiotic resistance OR antimicrobial resistance) AND (LMICs OR LMIC OR “low-and-middle income “ OR “Africa” OR Asia OR Afghanistan OR Albania OR Algeria OR Angola OR “Antigua and Barbuda” OR Argentina OR Armenia OR Azerbaijan OR Bangladesh OR Belarus OR Belize OR Benin OR Bhutan OR Bolivia OR “Bosnia and Herzegovina” OR Botswana OR Brazil OR “Burkina Faso” OR Burundi OR “Cabo Verde” OR Cambodia OR Cameroon OR “Central African Republic” OR Chad OR China OR Colombia OR Comoros OR “Democratic Republic of Congo” OR Congo OR “Cook Islands” OR “Costa Rica” OR “Côte d’Ivoire” OR Cuba OR Djibouti OR Dominica OR “Dominican Republic” OR Ecuador OR Egypt OR “El Salvador” OR “Equatorial Guinea” OR Eritrea OR Ethiopia OR Fiji OR Gabon OR Gambia OR Georgia OR Ghana OR Grenada OR Guatemala OR Guinea OR “Guinea-Bissau” OR Guyana OR Haiti OR Honduras OR India OR Indonesia OR		

TOPIC	SEARCH TERM	RESULT	RESULTS
	Iran OR Iraq OR Jamaica OR Jordan OR Kazakhstan OR Kenya OR Kiribati OR "Democratic People's Republic of Korea" OR Kosovo OR Kyrgyzstan OR Lao People's Democratic Republic OR Lebanon OR Lesotho OR Liberia OR Libya OR "Former Yugoslav Republic of Macedonia" OR Madagascar OR Malawi OR Malaysia OR Maldives OR Mali OR "Marshall Islands" OR Mauritania OR Mauritius OR Mexico OR Micronesia OR Moldova OR Mongolia OR Montenegro OR Montserrat OR Morocco OR Mozambique OR Myanmar OR Namibia OR Nauru OR Nepal OR Nicaragua OR Niger OR Nigeria OR Niue OR Pakistan OR Palau OR Panama OR Paraguay OR Peru OR Philippines OR Rwanda OR "Saint Helena" OR Samoa OR "São Tomé and Príncipe" OR Senegal OR Serbia OR Sierra Leone OR "Solomon Islands" OR Somalia OR "South Africa" OR "South Sudan" OR "Sri Lanka" OR "Saint Lucia" OR "Saint Vincent and the Grenadines" OR Sudan OR Suriname OR Swaziland OR "Syrian Arab Republic" OR Tajikistan OR Tanzania OR Thailand OR "Timor-Leste" OR Togo OR Tokelau OR Tonga OR Tunisia OR Turkey OR Turkmenistan OR Tuvalu OR Uganda OR Ukraine OR Uzbekistan OR Vanuatu OR Venezuela OR Vietnam OR "Wallis and Futuna" OR "West Bank and Gaza Strip" OR Yemen OR Zambia OR Zimbabwe)	PubMed	3,232

Agriculture and food sector

TOPIC	SEARCH TERM	RESULT	RESULTS
6 Increasing oversight of AMU by veterinarians			
Veterinary prescribing	(animal OR veterinar*) AND prescribing AND (guideline OR regulation) AND (antimicrobial OR antibiotic) AND (global OR LMICs OR LMIC OR "low-and-middle income countries" OR "developing countries" OR "Latin America" OR Africa OR Asia OR "South America" OR "Central America" OR Afghanistan OR Albania OR Algeria OR Angola OR "Antigua and Barbuda" OR Argentina OR Armenia OR Azerbaijan OR Bangladesh OR Belarus OR Belize OR Benin OR Bhutan OR Bolivia OR "Bosnia and Herzegovina" OR Botswana OR Brazil OR "Burkina Faso" OR Burundi OR "Cabo Verde" OR Cambodia OR Cameroon OR "Central African Republic" OR Chad OR China OR Colombia OR Comoros OR "Democratic Republic of Congo" OR Congo OR "Cook Islands" OR "Costa Rica" OR "Côte d'Ivoire" OR Cuba OR Djibouti OR Dominica OR "Dominican Republic" OR Ecuador OR Egypt OR "El Salvador" OR "Equatorial Guinea" OR Eritrea OR Ethiopia OR Fiji OR Gabon OR Gambia OR Georgia OR Ghana OR Grenada OR Guatemala OR Guinea OR "Guinea-Bissau" OR Guyana OR Haiti OR Honduras OR India OR Indonesia OR Iran OR Iraq OR Jamaica OR Jordan OR Kazakhstan OR Kenya OR Kiribati OR "Democratic People's Republic of Korea" OR Kosovo OR Kyrgyzstan OR Lao People's Democratic Republic OR Lebanon OR Lesotho OR Liberia OR Libya OR "Former Yugoslav Republic of Macedonia" OR Madagascar OR Malawi OR	PubMed	102

TOPIC	SEARCH TERM	RESULT	RESULTS
	Malaysia OR Maldives OR Mali OR “Marshall Islands” OR Mauritania OR Mauritius OR Mexico OR Micronesia OR Moldova OR Mongolia OR Montenegro OR Montserrat OR Morocco OR Mozambique OR Myanmar OR Namibia OR Nauru OR Nepal OR Nicaragua OR Niger OR Nigeria OR Niue OR Pakistan OR Palau OR Panama OR “Papua New Guinea” OR Paraguay OR Peru OR Philippines OR Rwanda OR “Saint Helena” OR Samoa OR “São Tomé and Príncipe” OR Senegal OR Serbia OR Sierra Leone OR “Solomon Islands” OR Somalia OR “South Africa” OR “South Sudan” OR “Sri Lanka” OR “Saint Lucia” OR “Saint Vincent and the Grenadines” OR Sudan OR Suriname OR Swaziland OR “Syrian Arab Republic” OR Tajikistan OR Tanzania OR Thailand OR “Timor-Leste” OR Togo OR Tokelau OR Tonga OR Tunisia OR Turkey OR Turkmenistan OR Tuvalu OR Uganda OR Ukraine OR Uzbekistan OR Vanuatu OR Venezuela OR Vietnam OR “Wallis and Futuna” OR “West Bank and Gaza Strip” OR Yemen OR Zambia OR Zimbabwe)		
Veterinary prescribing	veterinary prescribing guideline AND ("antibiotic use" OR "antimicrobial use")	Google Scholar	6,850 (First 250 results reviewed)
7 Monitoring of AMU, surveillance of AMR, and increasing oversight in plant/crop production			
Crop production	(“monitoring” OR “regulation” OR “supervision” OR “prescribing” OR “guideline”) AND (“intervention” OR “reduc*”) AND (“antimicrobial” OR “antibiotic” OR “resistance” OR “AMR”) AND (“crop” OR “orchard” OR “fruit production”)	PubMed	845
8 Improving animal husbandry practices and biosecurity			
Animal husbandry practices and biosecurity	(animal OR livestock OR farm) AND (hygiene OR biosecurity OR "animal health" OR welfare) AND (improvement OR enhance OR intervention) AND (infection OR disease OR treatment) AND ("antimicrobial use" OR "antibiotic use")	PubMed	303
9 Monitoring sales and use of antimicrobials and surveillance of AMR in animals			
Monitoring of sales and use of antimicrobials	(“monitoring system” OR “reporting system” OR database) AND (antibiotic OR antimicrobial) AND (sales OR use OR usage) AND (animal OR veterinary OR livestock OR farm) AND (“growth promoter” OR “critically important” OR trend OR track OR pattern)	PubMed	266
Surveillance of AMR in animals [Conducted for papers published through 2022]	(“monitoring system” OR “reporting system” OR “database” OR “surveillance”) AND (“antibiotic resistance” OR “antimicrobial resistance” OR “AMR” OR “resistant”) AND (“case” OR “incidence” OR “outbreak” OR “prevalence”) AND (animal OR veterinary OR livestock OR farm)	PubMed	1,415

TOPIC	SEARCH TERM	RESULT	RESULTS
10 Promoting behavior change campaigns in animal production			
Behavior change	(farmer OR veterinarian OR extension OR "animal production") AND ("antibiotic use" OR "antimicrobial use" OR antibiotics) AND ("behavior change" OR prudent OR "change in")	PubMed	193
11 Increasing veterinary laboratory capacity and access to diagnostics			
Increasing veterinary laboratory capacity	(“laboratory capacity” OR “diagnosis” OR “field-based” OR “mobile laboratory” OR sensitivity OR susceptibility OR quality) AND (“animal” OR “livestock” OR “veterinary”) AND (infection OR disease OR treatment) AND (“antimicrobial use” OR “antibiotic use”) AND (treatment OR prescribing)	PubMed	395

Water and environment sector

TOPIC	SEARCH TERM	RESULT	RESULTS
12 Improving infrastructure to provide access to water and sanitation in health care centers			
Improving infrastructure to provide access to water and sanitation in health centers [Conducted for papers published through 2022]	(“water” OR “sanitation” OR “hygiene” OR “WASH” OR “water, sanitation and hygiene” OR “IPC” OR “infection prevention” OR “infection control” OR “infection prevention and control”) AND (piping OR piped OR pipe OR running OR infrastructure) AND (“in hospital” OR “hospital setting” OR “clinic” OR “health center” OR “health care center” OR “health facility” OR “healthcare facility” OR “healthcare facilities”) AND (infection OR antimicrobial OR antibiotic OR burden OR resistance OR resistant OR “hand hygiene” OR “water quality”)	PubMed	287
13 Implementing effective treatment and disposal of sewage and wastewater			
Treatment and disposal of sewage and wastewater	(pharmaceutical manufacturing OR hospital OR urban OR municipal) AND (tertiary OR advanced) AND treatment AND (waste OR effluent) AND (antimicrobial OR antibiotic) AND (gene OR residue OR pathogen)	PubMed	86
Treatment and disposal of sewage and wastewater	(wastewater OR waste) AND "advanced treatment" AND antibiotic	Google Scholar	7,110 (First 250 results reviewed)
14 Improving waste management practices in agricultural and aquaculture production/processing			
Waste management practices in agricultural and aquaculture production/ processing	(“waste management” OR “manure treatment” OR “effluent treatment”) AND (intervention OR program) AND (agriculture OR aquaculture OR “on farms”) AND (resistance OR resistant OR residue)	PubMed	141

TOPIC	SEARCH TERM	RESULT	RESULTS
15 Improving safe disposal of unused antimicrobials			
Safe disposal	"take back" AND (antibiotic OR medication)	PubMed	147
Safe disposal	(“safe disposal” OR “take back”) AND (antibiotic OR medication) AND (global OR LMICs OR LMIC OR “low-and-middle income countries” OR “developing countries” OR “Latin America” OR Africa OR Asia OR “South America” OR “Central America” OR Afghanistan OR Albania OR Algeria OR Angola OR “Antigua and Barbuda” OR Argentina OR Armenia OR Azerbaijan OR Bangladesh OR Belarus OR Belize OR Benin OR Bhutan OR Bolivia OR “Bosnia and Herzegovina” OR Botswana OR Brazil OR “Burkina Faso” OR Burundi OR “Cabo Verde” OR Cambodia OR Cameroon OR “Central African Republic” OR Chad OR China OR Colombia OR Comoros OR “Democratic Republic of Congo” OR Congo OR “Cook Islands” OR “Costa Rica” OR “Côte d’Ivoire” OR Cuba OR Djibouti OR Dominica OR “Dominican Republic” OR Ecuador OR Egypt OR “El Salvador” OR “Equatorial Guinea” OR Eritrea OR Ethiopia OR Fiji OR Gabon OR Gambia OR Georgia OR Ghana OR Grenada OR Guatemala OR Guinea OR “Guinea-Bissau” OR Guyana OR Haiti OR Honduras OR India OR Indonesia OR Iran OR Iraq OR Jamaica OR Jordan OR Kazakhstan OR Kenya OR Kiribati OR “Democratic People’s Republic of Korea” OR Kosovo OR Kyrgyzstan OR Lao People’s Democratic Republic OR Lebanon OR Lesotho OR Liberia OR Libya OR “Former Yugoslav Republic of Macedonia” OR Madagascar OR Malawi OR Malaysia OR Maldives OR Mali OR “Marshall Islands” OR Mauritania OR Mauritius OR Mexico OR Micronesia OR Moldova OR Mongolia OR Montenegro OR Montserrat OR Morocco OR Mozambique OR Myanmar OR Namibia OR Nauru OR Nepal OR Nicaragua OR Niger OR Nigeria OR Niue OR Pakistan OR Palau OR Panama OR “Papua New Guinea” OR Paraguay OR Peru OR Philippines OR Rwanda OR “Saint Helena” OR Samoa OR “São Tomé and Príncipe” OR Senegal OR Serbia OR Sierra Leone OR “Solomon Islands” OR Somalia OR “South Africa” OR “South Sudan” OR “Sri Lanka” OR “Saint Lucia” OR “Saint Vincent and the Grenadines” OR Sudan OR Suriname OR Swaziland OR “Syrian Arab Republic” OR Tajikistan OR Tanzania OR Thailand OR “Timor-Leste” OR Togo OR Tokelau OR Tonga OR Tunisia OR Turkey OR Turkmenistan OR Tuvalu OR Uganda OR Ukraine OR Uzbekistan OR Vanuatu OR Venezuela OR Vietnam OR “Wallis and Futuna” OR “West Bank and Gaza Strip” OR Yemen OR Zambia OR Zimbabwe)	PubMed	103
Safe disposal	antibiotic AND (disposal OR "take back") AND (intervention OR program)	Google Scholar	18,700 (First 250 results reviewed)

TOPIC	SEARCH TERM	RESULT	RESULTS
16 Monitoring presence of antimicrobial residues and antibiotic-resistant			
Monitoring in water and sanitation systems	(monitoring OR surveillance OR detection) AND (“antimicrobial” OR “antibiotic” OR “antibiotic-resistant bacteria” OR “antibiotic resistant”) AND (“water system” OR “sanitation system” OR “water and sanitation system”)	PubMed	257

Multisectoral

TOPIC	SEARCH TERM	RESULT	RESULTS
17 Detecting and deterring substandard and falsified antimicrobials (customs/law enforcement/health/agriculture)			
Detecting and deterring substandard and falsified antimicrobials	"counterfeit" OR "falsified" OR "substandard" AND ("medicine" OR "antibiotics" OR "antimicrobials" OR "resistance")	PubMed	1,342
18 Improving nutrition in humans and animals (health/agriculture)			
Improving nutrition in humans and animals	("AMR" OR "antimicrobial resistance" OR "antibiotic resistance" OR "antimicrobial use" OR "antibiotic use") AND ("nutrition" OR "nutrient" OR "food security") AND ("reduction" OR "reduce")	PubMed	280
19 Expanding vaccination coverage in humans and animals (health/agriculture)			
Expanding vaccination coverage in humans and animals	("AMR" OR "antimicrobial resistance" OR "antibiotic resistance" OR "antimicrobial use" OR "antibiotic use") AND ("vaccination" OR "vaccine") AND ("reduction" OR "reduce")	PubMed	474
20 Using closed water systems in aquaculture (agriculture/environment)			
Closed water systems in aquaculture	("AMR" OR "antimicrobial resistance" OR "antibiotic resistance" OR "antimicrobial use" OR "antibiotic use") AND ("aquaculture" OR "fish") AND ("waste") AND ("integrated system" OR "closed system" OR "recirculating" OR “recirculate” OR "management" OR "treatment" OR "removal")	PubMed	45

Source: World Bank.

Note: Several topic searches included terms for income level, region, or country, using a set listing from the protocol by Pinto and Chandler (2020). This approach was used to narrow searches in cases where literature was extensive and appeared to be dominated by findings from high-income countries (primarily for health sector interventions); the goal was a more representative sample for review. Most searches were conducted in 2021 (specific exceptions are noted).

Table 17. Long List of Interventions

Primary sector (main sector able to take action)	**Drivers** (broad factors linked to risk)	**Issues** (more specific or proximal contributing factors)	**AMR-sensitive intervention** (broader initiatives that can reduce AMR risk or impact a co-benefit)	**AMR-specific intervention** (initiatives that have AMR reduction as their main purpose)	**Contextual considerations** (relevance for a given country)
Health; law enforcement	Substandard and falsified antibiotics	Poor quality (counterfeit, degraded, mislabeled, expired)	• Supply chain management/ traceability, including upon import • Closed drug distribution laws, rescheduling, and elimination of off-label use • Drug manufacturer authenticity partnerships (e.g., labeling, blockchain)	• Testing antimicrobials upon import • Antimicrobial registration • Monitoring, regulation, and enforcement infrastructure to detect and deter substandard or falsified antibiotics in the supply chain	Approach depends on portion/type of antibiotics imported vs. produced in country
Health; agriculture	Availability of antibiotics over the counter	Poor quality (counterfeit or degraded); inappropriate use	• Drug prescribing and sales laws and enforcement • Improved access to/utilization of formal health care system	• Antimicrobial prescribing and sales laws and enforcement (e.g., registration of sellers) • Point of sale instruction on use • Education of dispensers • Incentive programs for changing sales practices (stewardship)	Settings with high consumer demand for antibiotics and high burden of infections; low health care or diagnostic access
Health/ education	Limited public awareness and knowledge of antibiotics and antibiotic resistance	High demand; poor compliance in use and improper disposal	• Overall health literacy enhancement • Integrated approaches as part of prevention/control of sexually transmitted infections, vector-borne diseases (e.g., malaria), and livestock diseases: allows for targeted messaging to practitioners, sellers, and the public • Compliance support	• Compliance support to patients (e.g., phone call/telehealth/SMS reminders) • Centralized collection (e.g., via town halls, community health workers, etc.) • KAP studies and behavior change initiatives • Consumer/public outreach (e.g., school-based, social media)	Settings with a high burden of TB, malaria Frequent users of antimicrobials (for personal use or occupation)
Health	Limited availability or uptake of vaccines	Susceptibility to vaccine-preventable disease	• Community vaccination campaigns • R&D investment in accessible vaccines		Settings with a high burden of vaccine-preventable disease

Primary sector (main sector able to take action)	**Drivers** (broad factors linked to risk)	**Issues** (more specific or proximal contributing factors)	**AMR-sensitive intervention** (broader initiatives that can reduce AMR risk or impact a co-benefit)	**AMR-specific intervention** (initiatives that have AMR reduction as their main purpose)	**Contextual considerations** (relevance for a given country)
Health	Overprescribing/non-prudent use	Limited tracking and awareness by providers; limited health care access/ treatment options; incentives and demand; not completing the full treatment course	• Clinical guidelines on treatment • Clinical protocols to inform differential diagnosis (e.g., intake history) • Clinical decision support tools • Practitioner buy-in and engagement in stewardship • Possible AWaRe categorization	• Stewardship campaigns (e.g., rational prescribing, facility or provider prescribing audits, education/awareness campaigns, incentive campaigns) • Patient education on the importance of treatment completion • Pharmaceutical industry restrictions on antibiotic marketing • Antibiotic labeling	Several different contexts: settings with a high burden of endemic disease (e.g., malaria, typhoid); low continuity of care
Agriculture; food safety	Inadequate food safety regulations, monitoring, and controls	Overuse of antimicrobials and additives; limited traceability across the volume of trade and number of outlets; contamination along the food chain, including spoilage	• Food safety improvement measures and controls (identification of responsible authority, legislation, proper human and financial resources) • Hygiene measures in food preparation and storage (pasteurization, improved packaging, or cold storage) • Monitoring of risk and pharmaceutical use in the food system	• Regulations on AMU and residues in food production and supply • Harmonization to international standards, such as Codex Alimentarius, specifically TFAMR • Standard treatment guidelines (e.g., for prophylaxis, metaphylaxis, treatment) • Regulations, training, and enforcement for withdrawal periods • Pathogen and/or residue testing of foods on import and other points in the market chain • AMR monitoring in food animal handlers • Product (or farm) certification	Settings with inadequate food storage (e.g., cold chain)

Primary sector (main sector able to take action)	**Drivers** (broad factors linked to risk)	**Issues** (more specific or proximal contributing factors)	**AMR-sensitive intervention** (broader initiatives that can reduce AMR risk or impact a co-benefit)	**AMR-specific intervention** (initiatives that have AMR reduction as their main purpose)	**Contextual considerations** (relevance for a given country)
Agriculture (animal production)	Inappropriate volume of antibiotics used to grow livestock, poultry, and aquatic animals	High volume of AMU; non-judicious use; use of medically important antibiotics (e.g., colistin, aminoglycosides, macrolides, penicillins, quinolones, sulfonamides, tetracyclines); perceived benefits in animal production	• Awareness and uptake of good husbandry and welfare practices • Nature-based solutions for pest or pathogen control to reduce disease burden • Biosecurity/husbandry practices	• Regulation of AMU in animal production (regulatory change, training, enforcement) • Standard treatment (prescribing) guidance and essential medicines list for veterinary practice and animal production use • Regulation on AMU in animal production for prophylaxis and growth promotion • Training of practitioners (veterinarians/paraveterinarians, farmer associations, and/or consumers) on appropriate use (storage, dosing, application) • Resistant breeds • Product (or farm) certification • Public information campaigns (for veterinarians, farmers, or consumers)	Production system type (e.g., intensive, extensive, integrated): affects the flow of inputs and outputs
Agriculture (crop production)	Inappropriate volume of antibiotics used to grow crops; poor farm hygiene	High volume of AMU; nontargeted application allowing for environmental dissemination; contamination of crops by pests	• Nature-based solutions for pest and pathogen control to reduce disease burden (e.g., polycultures) • Use of local crop varieties with a natural resistance against pathogens and pests	• Regulation of AMU in crop production, including use of medically important antibiotics (regulatory change, training, enforcement) • Training of farmers on appropriate use (storage, dosing, application) • Resistant crop variants • AMU tracking • Market-based incentives for reduced AMU • Surveillance for residues in soil and handlers and on fruit	Production system type (e.g., organic vs. nonorganic); used for bacterial/fungal concerns and pest insects; typically certain fruit production (e.g., apple, pear)

Primary sector (main sector able to take action)	**Drivers** (broad factors linked to risk)	**Issues** (more specific or proximal contributing factors)	**AMR-sensitive intervention** (broader initiatives that can reduce AMR risk or impact a co-benefit)	**AMR-specific intervention** (initiatives that have AMR reduction as their main purpose)	**Contextual considerations** (relevance for a given country)
Agriculture (animal production)	Need to intensify animal production to meet increasing demand	High-density animal production; low drug absorption by animals; slow clearance of active pharmaceutical ingredients; dietary transitions (nutrition improvement, wild to domestic, excess)	• Improved livestock and agricultural productivity • Improved biosecurity and overall good practices to reduce disease risk (e.g., stock rates, appropriate husbandry, vaccination) • Treatment (chemical, biological) of influent and effluent • Improved disease diagnosis to support improved targeting of disease control measures • Reduced demand for excess protein (education, alternatives)	• Regulation of AMU in animal production, including use of medically important antibiotics (regulatory change, training, enforcement) • Alternatives to antibiotics: e.g., herbal therapy, phages	Transitional production systems where disease spread potential is likely to change as density increases; climate-related effects on prevalence of water- and vector-borne pathogens; varying nutrition status and access to animal protein alternatives
Agriculture (animal production)	Household sharing habitat with poultry and livestock	Infections from animal-human exposures	• WASH interventions to reduce potential for contamination • Biosecurity measures	• Restriction of AMU (human only, animal only) to protect efficacy of medically important antibiotics in animal and farmers	Smallholder production systems
Water/ environment	Sharing of surface waters by humans and animals	Potential for bacterial infections	• WASH interventions to reduce potential for contamination	• Pathogen and/or residue testing of water, source traceback, and treatment or contamination control measures	Low biosecurity; reliance on open water sources
Agriculture (animal production)	Limited access or uptake of veterinary vaccines	Susceptibility to vaccine-preventable diseases; poor access to differential diagnostics	• Improved provision of vaccines and vaccine uptake nudges through veterinary services • Improved storage and administration practices to promote efficacy	• Training of prescribers and farmers on appropriate AMU and disease reporting • Education of farmers	Settings without required vaccination; rural setting with limited infrastructure for vaccine cold storage/ distribution
Agriculture; food safety	Food consumption behaviors and preferences (i.e., raw or undercooked meat)	Pathogen exposures; antimicrobial residue exposures	• Cooking to address pathogen risks • Improved animal production and preparation practices to reduce pathogen load and AMU • Community education/awareness raising on safe food consumption, food-related risk	• Labeling with recommendations on preparation of food and its intended use	Low consumer awareness and limited risk communication

Primary sector (main sector able to take action)	**Drivers** (broad factors linked to risk)	**Issues** (more specific or proximal contributing factors)	**AMR-sensitive intervention** (broader initiatives that can reduce AMR risk or impact a co-benefit)	**AMR-specific intervention** (initiatives that have AMR reduction as their main purpose)	**Contextual considerations** (relevance for a given country)
Agriculture	Absence of farm biosecurity and frameworks for training farmers	Potential for contamination; lack of awareness	• Development of agricultural extension networks • Training on biosecurity	• AMU training provided directly to farmers and/or farming associations • Regulations and reporting system for AMU by farms	Limited access to veterinary services; informal/ inadequate existing biosecurity infrastructure
Environment	High levels of environmental contamination with antibiotic residues, heavy metals, and biocides	Susceptibility-weakened immune system (e.g., pesticide exposures); multi-resistance development to heavy metals and antibiotics; AMU to treat symptoms from toxicant exposures	• Soil/other environmental remediation • Policy/legislative interventions (e.g., restrictions on use and release of contaminants) • Waste management in/around ecotourism sites	• Restrictions on AMU • Effluent/waste treatment requirements for antimicrobial residues and synergistic contaminants prior to release into environment	Weak environmental services/governance
Agriculture (animal production)	Behaviors relating to the slaughter and processing of food animals	Food safety and waste disposal issues, including bacterial contamination; dissemination of ARGs	• Overall waste management practices in agricultural production/processing • Food safety legislation and enforcement at slaughterhouses/ abattoirs • Improved husbandry (legislation, training, infrastructure, certification) • WASH interventions to reduce potential for contamination (e.g., in abattoirs)	• Education of farmers on the law, enforcement of the regulations • Strengthening of veterinary services and extension services • Training at community level; training for farmers and paraprofessionals	Settings with limited access to extensions services
Agriculture; water	Irrigation with untreated wastewater	Bacterial contamination	• Wastewater treatment to address pathogen risks	• Wastewater treatment for residues and ARGs prior to use	Settings with limited access/ water shortages
Agriculture	Use of untreated animal waste for a variety of purposes, e.g., as fertilizer	Infection with antimicrobial-resistant pathogens due to antibiotics in waste; contamination of land and water sources	• Treatment of animal waste prior to use as fertilizer to address pathogen risks	• Animal waste treatment for residues and ARGs prior to use	

Primary sector (main sector able to take action)	**Drivers** (broad factors linked to risk)	**Issues** (more specific or proximal contributing factors)	**AMR-sensitive intervention** (broader initiatives that can reduce AMR risk or impact a co-benefit)	**AMR-specific intervention** (initiatives that have AMR reduction as their main purpose)	**Contextual considerations** (relevance for a given country)
Agriculture	Use of poultry waste as feed in aquaculture	Bacterial contamination; persistence of resistant genes in environmental reservoirs	• Closed systems: treatment of influent and effluent • Non-integrated poultry-aquaculture operations	• Reduction of unnecessary (e.g., nontherapeutic) AMU in poultry • Treatment of poultry waste prior to use • Where use has been widespread, may need to target ARGs persistent in environment	
Water	Untreated wastewater originating from pharmaceutical industries, hospitals, markets, manure, and sewage runoff	Dissemination into environment, including into waterways	• Regulation on active pharmaceutical ingredient manufacturing and audits • Waste treatment • Controlled entry of effluent into broader environment (e.g., surface water, rivers, agricultural plots, etc.)	• Regulations on effluent management • Regulations on antimicrobial waste management throughout manufacturing, use, and disposal spectrum • Monitoring for residues, pathogens, and genes • Waste treatment for residues, pathogens, and genes	

Primary sector (main sector able to take action)	**Drivers** (broad factors linked to risk)	**Issues** (more specific or proximal contributing factors)	**AMR-sensitive intervention** (broader initiatives that can reduce AMR risk or impact a co-benefit)	**AMR-specific intervention** (initiatives that have AMR reduction as their main purpose)	**Contextual considerations** (relevance for a given country)
Health; water	Overcrowding and poor sanitation and hygiene (health care facilities)	High potential for bacterial infections; uncontrolled cross-contamination in overcrowded wards; poor contact precautions; easy spread of resistant strains	• Other IPC and WASH measures in hospitals (improved cleaning, toilet facilities, waste management, equipment sharing and sanitation, IPC training, protocol implementation, monitoring and evaluation by IPC practitioners/ trained health workers) • Staff education on equipment and hand hygiene • Increase in segmented areas for patients with varying comorbidities • Isolation wards • IPC training, protocol implementation, monitoring and evaluation by IPC practitioners/ trained health workers • New or upgraded facilities designed to limit infection spread (e.g., ventilation)	• Waste/wastewater treatment from health care facility for residues, pathogens, and ARGs • Availability of handwashing/ • disinfection • "Offensive" and "defensive" infection control SOPs (managing standardized practice such as contact precautions post-diagnosis; protocol for infection prevention—i.e., prevention of surgical site contamination through equipment contamination) • Implementation of contact precautions and isolation procedures for patients with high-consequence AMR infections	Health care settings lacking designated areas for patients at high risk, or those with infectious illness
Water; urban	Overcrowding and poor sanitation and hygiene (community)	Prophylactic use; poor access to trained medical providers; exposure to animals/animal waste; high potential for bacterial infections; easy spread of resistant strains/conditions for mutations	• WASH interventions to reduce overall disease burden in community and household settings (e.g., schools) • Safe childhood play areas free of waste contamination	• Centralized toilet facilities with waste treatment for residues and/or genes • Sewage monitoring for pathogens and ARGs • Waste treatment for pathogens and ARGs	Informal settings; reliance on surface water; facilitated/ increased contamination due to flooding; exacerbated risk due to displacement from climate change and conflict situations

Primary sector (main sector able to take action)	**Drivers** (broad factors linked to risk)	**Issues** (more specific or proximal contributing factors)	**AMR-sensitive intervention** (broader initiatives that can reduce AMR risk or impact a co-benefit)	**AMR-specific intervention** (initiatives that have AMR reduction as their main purpose)	**Contextual considerations** (relevance for a given country)
Agriculture; water	Liquid waste from markets (blood, feces, wastewater) disposed into municipal drains through direct washout	Contamination of water sources	• Improved waste management before reuse • Off-site animal slaughter to centralize treatment of point source contamination	• AMR monitoring of wastewater and/or liquid waste	Live animal markets where slaughter occurs, local culture
Health; social development	Scarce data on the magnitude and economic burden of AMR in humans	Low detection/ tracking of impacts; few safety nets; minimal data on number of individuals per household	• Improved population-level detection and reporting • Vulnerability and impact assessments (e.g., climate-sensitive, food or water insecurity) • Reduced vulnerability to and impact of infections overall • Increased monitoring of local human migration patterns (i.e., rainy season causing influx into inland cities)	• Improved population-level detection and reporting • Vulnerability and impact assessments • Improved institutional governance and safety nets to mitigate vulnerability and cope with AMR impacts	

Primary sector (main sector able to take action)	**Drivers** (broad factors linked to risk)	**Issues** (more specific or proximal contributing factors)	**AMR-sensitive intervention** (broader initiatives that can reduce AMR risk or impact a co-benefit)	**AMR-specific intervention** (initiatives that have AMR reduction as their main purpose)	**Contextual considerations** (relevance for a given country)
Health; agriculture (animal health)	Weak surveillance, laboratory, and epidemiological capacity (and lack of resourcing)	Poor detection, diagnosis, and epidemiological understanding; unaffordable testing; poor monitoring of use trends and pathogens circulating	• Clinical protocols to inform differential diagnosis of infections (e.g., intake history) • Point of care diagnostics (e.g., rapid diagnostic tests) • Monitoring of pharmaceutical drug use (clinical and veterinary prescribing) and sales • Practitioner audits of prescribing history and behavior • Laboratory capacity for quality of veterinary medicinal products	• Regulatory requirement for reporting of antimicrobial use (prescribing or sales) and AMR—at health care facilities, points of sale, prescribers, farms, etc. • Susceptibility testing (individual or patient-level) to inform antimicrobial prescribing • AMR outbreak monitoring and tracking, including contact tracing to optimize which patients to test in the event of low testing supplies • Quality assurance of and reporting back on surveillance information • Low-cost, high-yield surveillance strategies (e.g., in sewage systems; whole genome sequencing for point source detection)	Setting with limited governance, monitoring infrastructure, and multisectoral coordination in AMR monitoring and action planning; limited existing guidance, lab, and surveillance capacities and regulations; substandard and falsified veterinary medicinal products

Source: World Bank compilation.

Note: This list is adapted from previous lists of drivers and expert input (see Table 15). Drivers do not represent equal risk or lead to equal impacts, and their relevance is context-specific for any given country. The scope is focused on issues pertinent to low- and middle-income countries. ARG = antimicrobial-resistant gene; AMU = antimicrobial use; AWaRe = access, watch, reserve; IPC= infection prevention and control; KAP = knowledge, attitudes, and practices; SOP = standard operating procedure; TB = tuberculosis; TFAMR = Ad Hoc Codex Intergovernmental Task Force on Antimicrobial Resistance; WASH = water, sanitation, and hygiene.

References

Pinto, C., and C. I. R. Chandler. 2020. "WASH and Biosecurity Interventions for Reducing Burdens of Infection, Antibiotic Use and Antimicrobial Resistance: A One Health Mixed Methods Systematic Review." London School of Hygiene and Tropical Medicine, et al. https://researchonline.lshtm.ac.uk/id/eprint/4657795/1/Pinto-Chandler-2020_WASH_and_biosecurity%20interventions_review.pdf.

Appendix 3
Environmental and Social Safeguards Guidance

Introduction

This appendix explains how the Environmental and Social Framework (ESF) can help client countries address antimicrobial resistance (AMR) through managing the environmental and social (E&S) risks and impacts of Investment Project Financing (IPF). The E&S policies and the 10 E&S Standards (ESSs) apply to all projects financed by the World Bank through IPF. The ESSs outline specific requirements for client countries to address in areas such as labor conditions, resource efficiency, community health, and natural resource management (see Box 14). The World Bank will support only those projects[50] that meet the requirements of the ESS in a manner and time frame acceptable to the World Bank.

Box 14. Overview of the Environmental and Social Standards

Overview of the Environmental and Social Standards

The ESF comprises 10 Environmental and Social Standards:

- **ESS1:** Assessment and Management of Environmental and Social Risks and Impacts
- **ESS2:** Labor and Working Conditions
- **ESS3:** Resource Efficiency and Pollution Prevention and Management
- **ESS4:** Community Health and Safety
- **ESS5:** Land Acquisition, Restrictions on Land Use and Involuntary Resettlement
- **ESS6:** Biodiversity Conservation and Sustainable Management of Living Natural Resources
- **ESS7:** Indigenous Peoples/Sub-Saharan African Historically Undeserved Traditional Local Communities
- **ESS8:** Cultural Heritage
- **ESS9:** Financial Intermediaries
- **ESS10:** Stakeholder Engagement and Information Disclosure

50 “Project” refers to the activities for which the World Bank provides support. Projects may include new facilities or activities and/or existing facilities or activities, or a combination of these. Projects may also include subprojects (World Bank 2017).

The Framework for Action describes 20 interventions across agriculture, the environment, health, and water; investments in these areas can support low- and middle-income countries in strengthening and developing agriculture, health, and water and sanitation systems that prevent the emergence of diseases and thus reduce AMR (see Table 18). Application of the ESSs in IPF operations can provide entry points for these interventions and appropriate mitigations. Recommendations for mitigation measures should be tailored to the specific type of risks identified for the specific intervention and its given context. This guidance will provide a systematic approach to the identification, assessment, and mitigation of related risks with clearly defined roles for both client country and the World Bank.

Table 18. Intervention Areas for Addressing AMR, by Sector

Sector	No.	Intervention
Health	1	Improving infection prevention and control in health care settings
Health	2	Improving prescribing practices through guidelines for health care workers
Health	3	Conducting public awareness campaigns
Health	4	Increasing human health laboratory capacity and access to diagnostics
Health	5	Strengthening surveillance of antimicrobial use (AMU) and AMR in human populations
Agriculture and food	6	Increasing oversight of AMU by veterinarians
Agriculture and food	7	Monitoring AMU, surveillance of AMR, and increasing oversight in plant/crop production
Agriculture and food	8	Improving animal husbandry practice and biosecurity
Agriculture and food	9	Monitoring sales and use of antimicrobials and surveillance of AMR in animals
Agriculture and food	10	Promoting behavior change campaigns in animal production
Agriculture and food	11	Increasing veterinary laboratory capacity and access to diagnostics
Water and environment	12	Improving infrastructure to provide access to water and sanitation in health care centers
Water and environment	13	Implementing effective treatment and disposal of sewage and wastewater
Water and environment	14	Improving waste management practices in agricultural and aquaculture production/processing
Water and environment	15	Improving safe disposal of unused antimicrobials
Water and environment	16	Monitoring presence of antimicrobial residues and antibiotic-resistant bacteria and genes in water and sanitation systems
Multisectoral	17	Detecting and deterring substandard and falsified antimicrobials (customs/law enforcement/health/agriculture)
Multisectoral	18	Improving human and animal nutrition (health/agriculture)
Multisectoral	19	Expanding vaccination coverage in humans and animals (health/agriculture)
Multisectoral	20	Using closed water systems in aquaculture (agriculture/environment)

Source: World Bank. Note: AMU = antimicrobial use.

Objectives and scope

ESS1 (Assessment and Management of Risks) and ESS10 (Stakeholder Engagement) set out client countries' responsibility for assessing, managing, and monitoring E&S risks. ESS1 provides for an E&S assessment of the proposed project, engagement with stakeholders, disclosure of appropriate information, development of an Environmental and Social Commitment Plan (ESCP), and assessment, monitoring, and reporting on the performance of the project against the ESSs. ESS10 on stakeholder engagement must be read in conjunction with ESS1—that is, it should be recognized that effective stakeholder engagement can improve environmental and social sustainability of projects, enhance project acceptance, and make a significant contribution to successful project design and implementation. ESS10 includes a systematic approach to enabling stakeholders' views to be considered in project design and environmental and social performance.

The primary objective of this guidance is to support World Bank staff, including E&S specialists and task teams, in engaging with client countries to manage risks related to the identified AMR-related interventions. Section 1 focuses on understanding E&S risks and conducting E&S assessments. Section 2 discusses potentially significant AMR-related risks and impacts on gender. Section 3 describes approaches to stakeholder engagement. Section 4 guides actions for mitigation required for meeting the ESSs.

Section 1. Environmental and social assessment of AMR projects

The client country's E&S assessment includes environmental risks and impacts, such as those related to community safety, climate change, and ecosystem services, as well as social risks and impacts, such as the risk that a project disproportionately and negatively affects disadvantaged or vulnerable individuals or groups. Resistant microorganisms occur not only in people and animals, but also in contaminated food and water sources and more broadly in the environment. Resistant microorganisms and genes can be transmitted through various pathways, such as person-to-person contact, person-to-animal contact, consumption of contaminated foods, and contact with human and agricultural wastes. The environmental dimension of AMR has received comparatively less focus than AMR in human or animal health. However, evidence indicates that the release of antimicrobial compounds into the environment, coupled with direct contact between natural bacterial communities and discharged resistant bacteria, is driving bacterial evolution and the emergence of more resistant strains (UNEP 2017). A Review on Antimicrobial Resistance (2016) report highlights the need to reduce antibiotic pollution of the environment through three pathways: (i) municipal and industrial wastewater, such as from households, health care facilities, manufacturing, and pharmacies; (ii) land spreading of animal manure and sewage sludge from animal production; and (iii) aquaculture.

ESS1, ESS2, ESS3, ESS4, ESS6, and ESS10 are relevant to AMR and related risks to humans, animals, and the environment. Table 19 aims to support the E&S assessment of 20 AMR-related interventions by identifying risks and impacts of each intervention as well as options for mitigating them. The table should help World Bank staff identify good practices/mitigation measures aligned with these and similar interventions.

These ESSs provide entry points for the control of AMR; for projects supporting livestock and aquaculture production, health care facilities (HCFs), and WASH (water, sanitation, and hygiene) services, impact assessment and mitigation should consider risks such as the introduction of resistant microbes into natural ecosystems. Addressing the impact of ecosystems on AMR spread and emergence, and vice versa, as well as the impact of AMR on certain individuals and groups, will be relevant in complying with the ESSs, including the selection of stakeholders and preparing the ESCP.

Mitigation measures and good practices are tailored to the level of risk and project specificities and can be summarized within five main groupings of interventions: (i) infection prevention and control, (ii) policy and guidelines for limiting use of antimicrobials, (iii) waste and wastewater management, (iv) surveillance and monitoring, and (v) quality testing of antimicrobials for use. Each of the groupings includes interventions that can be applied across different sectors. Strong infection prevention and control measures are considered the most effective and cost-efficient way of controlling the spread of AMR. The most effective intervention is to improve hygiene in health centers, schools, and other public facilities, in part through promotion of hand hygiene and better hospital hygiene. Preventing and controlling infections on farms entails use of biosecurity measures, including better hygiene, records of farm visitors, and disinfection of vehicles entering the farm area. Policy and guidelines for limiting use of antimicrobials include public awareness campaigns and antimicrobial guidelines, including vaccination strategies, stewardship, and changing regulations around prescribing and reimbursement. Waste and wastewater management practices can reduce the risk of introducing antimicrobial-resistant bacteria and genes into the environment.

Table 19. Environmental and Social Assessment of AMR Projects

Health sector

AMR INTERVENTION	ENTRY POINTS IN ESS	RISK TO AMR INTERVENTION	OPTIONS FOR MITIGATION TO AMR INTERVENTION
1 **Improving infection prevention and control in health care settings**	• Limited access to WASH facilities or important components of hygiene and sanitation kits, such as soap (ESS2, ESS3, ESS4) • Poor infection and disease prevention control in health care facilities (ESS2, ESS4)	• Poor access to diagnostics, vaccines, and affordable medicines (ESS4) • Poor design and layout of HCFs, which impedes separation of clean/ sterilized and dirty/ contaminated materials and people flows (ESS1, ESS2, ESS3, ESS4)	• Hold regular training sessions. • Ensure prior design of HCF by experienced health care design engineer. • Develop and include adequate disinfection/sterilization procedures and facilities. • Select HCF-appropriate HVAC systems that provide isolation and protection from airborne infections. • Select easily cleaned building materials that do not promote microbiological growth.
2 **Improving prescribing practices through guidelines for health care workers**	• Limited access to trained health care workers and antimicrobials (ESS1, ESS2, ESS4)	• Absence of the well-functioning diagnostics system needed to improve patient outcomes (ESS4)	• Develop prescribing guidelines that consider access to health care facilities and health care workers.
3 **Conducting public awareness campaigns**	• Limited health literacy, which results in increased demand for and use of antimicrobials (ESS4, ESS10)	• Lack of outreach to areas with the most limited health literacy (ESS4, ESS10)	• Develop education materials that are nondiscriminatory and provide equal opportunities for behavior change. • Engage stakeholders to provide insights into what would lead to behavioral changes among different groups.
4 **Increasing human health laboratory capacity and access to diagnostics**	• Laboratory capacity that is limited and not in compliance with international standards (ESS2, ESS4)	• Lack of trained personnel for out-of-date equipment, electricity failures, and stock-out of laboratory consumables (ESS2) • Lack of integrated waste management systems in health care and hence no processes for minimizing, reusing, and recycling waste to implement source reduction and waste toxicity reduction, or to provide adequate on-site handling, collection, storage, and transport of waste (ESS3, ESS4)	• Improve monitoring of antimicrobial use and surveillance of emergence of AMR by strengthening laboratory capacity and developing systems for gathering data on how the public health sectors access and use antimicrobials. • Improve rapid diagnostic methods for infectious diseases in humans, including susceptibility testing, to target appropriate treatments and determine specifically if antimicrobials are appropriate. • Ensure that HCFs establish, operate, and maintain health care waste management systems adequate for the scale and type of activities and identified hazards.

AMR INTERVENTION	ENTRY POINTS IN ESS	RISK TO AMR INTERVENTION	OPTIONS FOR MITIGATION TO AMR INTERVENTION
5 **Strengthening surveillance of antimicrobial use (AMU) and AMR in human populations**	• Lack of information on amounts of antimicrobials sold in informal markets (ESS4) • Lack of a baseline to measure the reduction of antimicrobial use (ESS4) • Lack of public or private standards for antimicrobial registration, manufacturing, distribution, or sales and use (ESS2, ESS4)	• Lack of surveillance and monitoring systems • Lack of risk communication systems, so that resources put into early detection will not support investigations of outbreaks (ESS1, ESS2, ESS4)	• Implement a surveillance, monitoring, and risk communication system that can be accessed by all relevant parties. • Establish national targets for the reduction of antimicrobial use in livestock, especially for nontherapeutic usages; assist countries in presenting annual progress reports to the Tripartite AMR country self-assessment survey of the WHO/FAO/WOAH. • Provide an enabling environment by strengthening public and private standards for the registration, manufacture, distribution, sale, and use of antimicrobials throughout the supply chain, including implementation and enforcement of standards.

Agriculture and food sector

AMR INTERVENTION	ENTRY POINTS IN ESS	RISK TO AMR INTERVENTION	OPTIONS FOR MITIGATION TO AMR INTERVENTION
6 **Increasing oversight of AMU by veterinarians**	• Use of veterinary medicinal products in the wrong circumstances or in manner not in accordance with prescribed conditions or dosages, leading to increased drug resistance in animals and food contamination due to drug residues; use of substandard and falsified antimicrobials, also contributing to the emergence of AMR (ESS3, ESS4, ESS6)	• Spread of infectious diseases, such as foot and mouth disease or African swine fever, by animal health workers working across a community (ESS2, ESS3, ESS4) • Addition of antimicrobials to feed for growth promotion or other nontherapeutic use (ESS3, ESS4, ESS6)	• Develop viable alternatives for farmers to transition away from reliance on antimicrobials. • Strengthen education, training, and communication at national levels, with particular focus on veterinary education and the role of veterinarians and veterinary para-professional standards in governing the use of antimicrobials in livestock. • Identify production systems that are heavily reliant on drugs and critical points in animal life cycles where the use of antimicrobials is highest, to provide entry points for interventions. • Implement national targets for reducing or banning the use of antimicrobials for growth promotion and promote the use of probiotics, prebiotics, organic acids, or zeolites as alternatives.

AMR INTERVENTION	ENTRY POINTS IN ESS	RISK TO AMR INTERVENTION	OPTIONS FOR MITIGATION TO AMR INTERVENTION
7 Monitoring AMU, surveillance of AMR, and increasing oversight in plant/ crop production	• Lack of information on amounts of antimicrobials sold in informal markets (ESS4) • Lack of a baseline to measure the reduction of antimicrobial use (ESS4, ESS6) • Lack of public or private standards for antimicrobial registration, manufacturing, distribution, or sales and use (ESS2, ESS4)	• Lack of surveillance and monitoring systems that can distinguish potential sources of antimicrobial contamination in crop production • Lack of suitable alternatives • Limited understanding of the direct epidemiological relevance of residue detection and AMR in crops for human health • Lack of risk communication systems, so that resources put into early detection will not support investigations of outbreaks (ESS1, ESS2, ESS4)	• Implement a surveillance, monitoring, and risk communication system that can be accessed by all relevant parties. • Establish national targets for the reduction of antimicrobial use in crop production, especially for nontherapeutic usages; assist countries in presenting annual progress reports to the Tripartite AMR country self-assessment survey of the WHO/FAO/WOAH. • Provide an enabling environment by strengthening public and private standards for the registration, manufacture, distribution, sale, and use of antimicrobials throughout the supply chain, including implementation and enforcement of standards.
8 Improve animal husbandry practice and biosecurity	• Poorly designed farms leading to increased incidence of disease and poor animal welfare (ESS3, ESS4, ESS6) • A high density and concentration of animals favoring the emergence and spread of infectious diseases, including zoonotic diseases (ESS3, ESS4, ESS6) • Poor welfare in animals, impacting their ability to provide expected services or production (ESS3, ESS6) • Reliance on management practices that induce poor welfare of animals (ESS1, ESS3, ESS4, ESS6)	• Absence of waste treatment on farms that are intensifying production, leading to increase in risks related to pollution, such as water contamination by farm effluents, which can become a transmission channel of AMR (ESS3, ESS4, ESS6)	• Investigate field conditions to identify ways to redesign production systems and animal husbandry practices that rely less on antimicrobials, including upgrading of housing, genetic selection, vaccination strategies, dietary adjustments, improved hygiene procedures, and staff training. • Improve biosecurity and access to vaccines. • Undertake economic and feasibility studies to identify how to adjust production systems to reduce the use of antimicrobials without compromising food supply or animal health and welfare. • Raise awareness of, and educate professionals and livestock owners to better understand, how antimicrobials function, the potential adverse consequences of inappropriate use, and possible alternatives to their use. • Develop appropriate vaccines and vaccination strategies with the specific objective of reducing the use of antimicrobials in livestock.

AMR INTERVENTION	ENTRY POINTS IN ESS	RISK TO AMR INTERVENTION	OPTIONS FOR MITIGATION TO AMR INTERVENTION
9 Monitoring sales and use of antimicrobials and surveillance of AMR in animals	• Lack of information on amounts of antimicrobials sold in informal markets (ESS3, ESS4, ESS6) • Lack of a baseline to measure the reduction of antimicrobial use (ESS4, ESS6) • Lack of public or private standards for antimicrobial registration, manufacturing, distribution, sales, or use (ESS2, ESS4, ESS6)	• Absence of risk communication systems, implying that resources put into early detection will not support investigations of outbreaks (ESS1, ESS2, ESS4)	• Establish national targets for the reduction of antimicrobial use in livestock, especially for nontherapeutic usages; assist countries in presenting annual progress reports to the Tripartite AMR country self-assessment survey of the WHO/FAO/WOAH. • Provide an enabling and regulatory environment by strengthening public and private standards for the registration, manufacture, distribution, sale, and use of antimicrobials throughout the supply chain, including implementation and enforcement of standards.
10 Promote behavior change campaigns in animal production	• Limited knowledge of alternatives to antimicrobial use, resulting in increased demand for and use of antimicrobials (ESS4, ESS10)	• Lack of outreach to areas with the most limited health literacy (ESS2, ESS4, ESS6, ESS10)	• Develop education materials that are nondiscriminatory and provide inclusive opportunities for behavior change.
11 Increase veterinary laboratory capacity and access to diagnostics	• Laboratory capacity that is limited and not in compliance with international standards (ESS2, ESS3, ESS4)	• Lack of trained personnel (ESS2)	• Improve monitoring of antimicrobial use and surveillance of emergence of AMR by strengthening laboratory capacity and developing systems for gathering data on how national livestock sectors access and use antimicrobials, including identification, traceability, and measurement of antimicrobial residues in livestock food products. • Improve rapid diagnostic methods for infectious diseases in livestock, fish, and crops, including susceptibility testing, to target appropriate treatments and determine specifically if antimicrobials are appropriate.

Water and environment sector

AMR INTERVENTION	ENTRY POINTS IN ESS	RISK TO AMR INTERVENTION	OPTIONS FOR MITIGATION TO AMR INTERVENTION
12 Improving infrastructure to provide access to water and sanitation in health care centers	• Lack of access to adequate water and sanitation in a high-volume setting, potentially leading to infection and onward transmission of disease (ESS3, ESS4, ESS6)	• Diversified access in terms of city- or village-wide water system improvement (ESS3, ESS4, ESS6) • Other sources of infection (e.g., at home), which likely diminish the potential benefits of infrastructure improvements in schools and other communal settings (ESS3, ESS4, ESS6)	• Include wastewater composition analysis in the design of advanced wastewater treatment interventions. • Ensure that water systems can provide adequate supplies of potable water to reduce risks of exposure to Legionella and other waterborne pathogens.
13 Implementing effective treatment and disposal of sewage and wastewater	• Untreated effluent and dissemination of residues and resistant pathogens and genes from hospital effluent and other sources, which presents potential risks of dissemination via drinking water, irrigation, and aquatic environments, including through surface water contamination (ESS3, ESS4, ESS6)	• Poor understanding of how different technologies and practices across production systems may potentially increase or decrease presence and dissemination of resistant pathogens on the ground (ESS3, ESS4, ESS6)	• Include wastewater composition analysis in the design of advanced wastewater treatment interventions. • Use proper waste management practices.
14 Improving waste management practices in agricultural and aquaculture production/processing	• Absence of waste treatment on farms that are intensifying production, leading to increase in risks related to pollution, such as water contamination by farm effluents, which can become a transmission channel of AMR (ESS2, ESS3, ESS4, ESS6)	• Poor understanding of how different technologies and practices across production systems may potentially increase or decrease presence and dissemination on the ground (ESS3, ESS4, ESS6)	• Undertake economic and feasibility studies to identify how to adjust production systems to reduce the use of antimicrobials without compromising food supply or animal health and welfare. • Use proper waste management in agriculture and aquaculture. • Educate farmers on optimal use of waste treatment technologies to support implementation success.
15 Improving safe disposal of unused antimicrobials	• Limited knowledge of the precise level of threat from residues and genes transmitted through waste and wastewater (ESS3, ESS4, ESS6)	• Community- or individual-level behaviors, which may increase or decrease risk (ESS3, ESS4, ESS6)	• Review uptake of safe disposal programs for all medicines for evidence of effectiveness. • Increase public awareness to reduce demand; monitor antimicrobial use, access to diagnostics, and proper dosage.

AMR INTERVENTION	ENTRY POINTS IN ESS	RISK TO AMR INTERVENTION	OPTIONS FOR MITIGATION TO AMR INTERVENTION
16 **Monitoring presence of antimicrobial residues and antibiotic-resistant bacteria and genes in water and sanitation systems**	• Lack of knowledge of AMR exposure routes and transmission channels (ESS3, ESS4, ESS6)	• Community- or individual-level behaviors, which may increase or decrease risk (ESS3, ESS4, ESS6)	• Improve monitoring and comparison to background environmental data to support more precise monitoring needs (samples and sites; antibiotics, bacteria, and genes to screen for) and better interpretation of findings.

Multisector

AMR INTERVENTION	ENTRY POINTS IN ESS	RISK TO AMR INTERVENTION	OPTIONS FOR MITIGATION TO AMR INTERVENTION
17 **Detecting and deterring substandard and falsified antimicrobials**	• Use of falsified antimicrobials, which can reduce effective treatment for both humans and animals (ESS3, ESS4)	• Absence of risk communication systems, implying that resources put into early detection will not support investigations of outbreaks (ESS1, ESS2, ESS4)	• Register and test antimicrobials, including upon import. • Monitor, regulate, and enforce infrastructure to detect and deter substandard or falsified antibiotics in the supply chain. • Establish drug manufacturer authenticity partnerships (e.g., for labeling).
18 **Improving human and animal nutrition**	• Limited knowledge of alternatives to antimicrobial use in animal production, such as improved animal nutrition as an alternative to antimicrobials for growth promotion (ESS4, ESS10) • Poor access to nutritional resources due to lack of food safety or food security (ESS3, ESS4, ESS6)	• Community- or individual-level behaviors, which may increase or decrease risk (ESS3, ESS4, ESS6) • Food insecurities that affect access to and sustainment of nutrition resources (ESS3, ESS4, ESS6)	• Investigate field conditions to identify ways to redesign production systems and animal husbandry practices that rely less on antimicrobials, including upgrading of housing, genetic selection, vaccination strategies, dietary adjustments, improved hygiene procedures, and staff training. • Develop campaign materials that are nondiscriminatory and provide inclusive opportunities for behavior change. • Establish national targets for the reduction of antimicrobial use in livestock, especially for nontherapeutic usages, and assist countries in identifying improved animal nutrition as an alternative to their use. • Implement food and feed safety compliance systems to help reduce exposure to pathogens and antibiotic residues in the food supply.

AMR INTERVENTION	ENTRY POINTS IN ESS	RISK TO AMR INTERVENTION	OPTIONS FOR MITIGATION TO AMR INTERVENTION
19 Expanding vaccination coverage in humans and animals	• Poor access to diagnostics, vaccines, and affordable medicines (ESS3, ESS4)	• Lack of infrastructure (e.g., cold chain) to distribute vaccines (ESS4) • Vaccine hesitancy in populations (ESS4)	• Investigate field conditions to identify ways to redesign production systems and animal husbandry practices that rely less on antimicrobials, including upgrading of housing, genetic selection, vaccination strategies, dietary adjustments, improved hygiene procedures, and staff training. • Develop campaign materials that are nondiscriminatory and provide inclusive opportunities for behavior change. • Provide an enabling environment for the distribution, sale, and use of vaccines throughout the supply chain.
20 Using closed water systems in aquaculture	• Lack of knowledge of AMR exposure routes and transmission channels (ESS3, ESS4, ESS6) • Absence of waste treatment on farms that are intensifying production, leading to increase in risks related to pollution, such as water contamination by farm effluents, which can become a transmission channel of AMR (ESS2, ESS3, ESS4, ESS6)	• Poor understanding of how different technologies and practices across production systems may potentially increase or decrease presence and dissemination on the ground (ESS3, ESS4, ESS6)	• Investigate field conditions to identify ways to redesign production systems and animal husbandry practices that rely less on antimicrobials, including upgrading of housing, genetic selection, vaccination strategies, dietary adjustments, improved hygiene procedures, and staff training. • Provide water systems to reduce wastewater pollution.

Source: World Bank.

Note: ESS = Environmental and Social Standard; FAO = Food and Agriculture Organization of the United Nations; HCF = health care facilities; HVAC = heating, ventilation, and air conditioning; WASH = water, sanitation, and hygiene; WHO = World Health Organization; WOAH = World Organisation for Animal Health.

Section 2. AMR-related risks to and impacts on gender and vulnerable groups

The World Bank's overall approach to gender is guided by the World Bank Gender Strategy and OP4.20: Gender and Development. The ESF addresses gender risks in both the process and methodology of the E&S assessment; the aim is to assess the potential risks and impacts of the project that may fall disproportionately on the disadvantaged or vulnerable and to identify any prejudice or discrimination toward such groups in providing access to development resources and project benefits. ESS1, ESS2, ESS4, and ESS10 set standards for gender equality and inclusion to be addressed by client countries.

To ensure that interventions addressing AMR are effective, it is important to understand how both AMR and AMR interventions can present a risk to men and women as well as vulnerable groups. The choice of gender-responsive mitigation activities will depend on a good understanding of the context in which a project is intended to operate, derived from a detailed analysis of gender roles, responsibilities, and power relations. Table 20 presents examples of gender-responsive activities, approaches, and actions in AMR interventions.

Table 20. Examples of Activities to Integrate Gender and Vulnerable Groups in AMR Projects

AMR considerations (WHO 2018; ReAct 2020)	**Vulnerable group**	**AMR intervention**	**Gender-responsive activities by ESS**
Risk during pregnancy, abortion, and childbirth: Increasing AMR may raise women's risk of exposure to AMR during pregnancy, abortion, and cThildbirth, especially where these events take place in health care settings without safe or hygienic conditions.	Women	• Improving hand hygiene in health care settings • Improving infrastructure to provide access to WASH in HCF, schools, and other facilities • Improving infection prevention and control • Improving prescribing guidelines for health care workers • Strengthening surveillance of AMR in human populations • Increasing human health laboratory capacity	• Assess risk that any harm caused by projects falls disproportionately on the disadvantaged or vulnerable; assess any prejudice or discrimination toward such groups in providing access to development resources and project benefits (ESS1). • Avoid or minimize the potential for community exposure to diseases that could result from project activities (including waterborne, water-based, water-related, and vector-borne diseases and both communicable and noncommunicable diseases), taking into consideration differentiated exposure and higher sensitivity of vulnerable groups (ESS4). • Identify the disadvantaged or vulnerable (ESS10). • Describe in the Stakeholder Engagement Plan what measures will be used to remove obstacles to participation, and how the views of differently affected groups will be captured (ESS10).

AMR considerations (WHO 2018; ReAct 2020)	Vulnerable group	AMR intervention	Gender-responsive activities by ESS
			• Provide stakeholders with access to the information on potential risks and impacts that might disproportionately affect the vulnerable and disadvantaged, and describe the differentiated measures taken to avoid and minimize these (ESS10).
Urinary tract infections (UTIs): An increasing number of antibiotic-resistant strains combined with expansion of efforts to tackle AMR is making the effective treatment of UTIs more complicated.	Elderly men and women (UTIs are eight times more common for women)	• Improving hand hygiene in health care settings • Improving infrastructure to provide access to WASH in HCF, schools, and other facilities • Improving infection prevention and control • Improving prescribing guidelines for health care workers • Strengthening surveillance of AMR in human populations • Increasing human health laboratory capacity	• Assess risk that any harm caused by projects falls disproportionately on the disadvantaged or vulnerable; assess any prejudice or discrimination toward such groups in providing access to development resources and project benefits (ESS1). • Avoid or minimize the potential for community exposure to diseases that could result from project activities (including waterborne, water-based, water-related, and vector-borne diseases and both communicable and noncommunicable diseases), taking into consideration differentiated exposure and higher sensitivity of vulnerable groups (ESS4). • Identify the disadvantaged or vulnerable (ESS10). • Describe in the Stakeholder Engagement Plan what measures will be used to remove obstacles to participation, and how the views of differently affected groups will be captured (ESS10). • Provide stakeholders with access to information on potential risks and impacts that might disproportionately affect the vulnerable and disadvantaged, and describe the differentiated measures taken to avoid and minimize these (ESS10).
Gonorrhea: With close to 80 million new cases every year, gonorrhea is one of the most common sexually transmitted diseases. Gonorrhea has over time developed resistance to each of the antibiotics used for treatment, and some cases of gonorrhea are now untreatable or nearly so.	Men who have sex with men, indigenous people, women	• Improving infection prevention and control • Improving prescribing guidelines for health care workers • Strengthening surveillance of AMR in human populations • Increasing human health laboratory capacity • Conducting public awareness campaigns	• Assess risk that any harm caused by projects falls disproportionately on the disadvantaged or vulnerable; assess any prejudice or discrimination toward such groups in providing access to development resources and project benefits (ESS1). • Evaluate and address project's risks for and impacts on the health and safety of the affected communities, including the vulnerable, during the project life cycle (ESS4).

AMR considerations (WHO 2018; ReAct 2020)	Vulnerable group	AMR intervention	Gender-responsive activities by ESS
		• Detecting and deterring substandard and falsified antimicrobials	• Identify the disadvantaged or vulnerable (ESS10). • Describe in the Stakeholder Engagement Plan what measures will be used to remove obstacles to participation, and how the views of differently affected groups will be captured (ESS10). • Provide stakeholders with access to the information on potential risks and impacts that might disproportionately affect the vulnerable and disadvantaged, and describe the differentiated measures taken to avoid and minimize these (ESS10).
Health care workers: Women globally make up 67 percent of health care workers and have a vital role in addressing AMR, both through appropriate prescribing and dispensing of antimicrobial medicines and through ensuring clean care for all patients.	Women, health care workers	• Improving infection prevention and control • Improving prescribing guidelines for health care workers • Conducting public awareness campaigns • Improving infrastructure to provide access to WASH in HCF, schools, and other facilities • Improving safe disposal of unused antimicrobials	• Assess risk that any harm caused by projects falls disproportionately on the disadvantaged or vulnerable; assess any prejudice or discrimination toward such groups in providing access to development resources and project benefits (ESS1). • Provide appropriate measures of protection and assistance to address the vulnerabilities of project workers, including women (ESS2). • Evaluate and address project's risks for and impacts on the health and safety of the affected communities, including the vulnerable, during the project life cycle (ESS4). • Identify the disadvantaged or vulnerable (ESS10). • Describe in the Stakeholder Engagement Plan what measures will be used to remove obstacles to participation, and how the views of differently affected groups will be captured (ESS10). • Provide stakeholders with access to information on potential risks and impacts that might disproportionately affect the vulnerable and disadvantaged, and describe the differentiated measures taken to avoid and minimize these (ESS10).

AMR considerations (WHO 2018; ReAct 2020)	**Vulnerable group**	**AMR intervention**	**Gender-responsive activities by ESS**
Workers in livestock and fish farming or manufacturing: People employed in farming of livestock and fish as well as in manufacturing companies may be more exposed than others to animals carrying resistant bacteria.	Farmers, farmer's families and friends, veterinarians	• Improving the quality of veterinary medicinal products and their use under supervision by veterinarians • Improving animal husbandry practice • Conducting behavior change campaigns and providing alternatives in animal production • Increasing veterinary laboratory capacity • Improving infection prevention and control • Improving infrastructure to provide access to WASH in HCF, schools, and other facilities	• Assess risk that any harm caused by projects falls disproportionately on the disadvantaged or vulnerable; assess any prejudice or discrimination toward such groups in providing access to development resources and project benefits (ESS1). • Ensure the projects do not inadvertently compromise existing legitimate rights for land and natural resource tenure and use, and that they do not have unintended consequences (ESS1). • Provide appropriate measures of protection and assistance to address the vulnerabilities of project workers, including women (ESS2). • Avoid or minimize the potential for community exposure to diseases that could result from project activities (including waterborne, water-based, water-related, and vector-borne diseases and both communicable and noncommunicable diseases), taking into consideration differentiated exposure and higher sensitivity of vulnerable groups (ESS4). • Identify the disadvantaged or vulnerable (ESS10). • Describe in the Stakeholder Engagement Plan what measures will be used to remove obstacles to participation, and how the views of differently affected groups will be captured (ESS10). • Provide stakeholders with access to information on potential risks and impacts that might disproportionately affect the vulnerable and disadvantaged, and describe the differentiated measures taken to avoid and minimize these (ESS10).

Source: World Bank.

Note: ESS = Environmental and Social Standard; HCF = health care facilities; WASH = water, sanitation, and hygiene.

Section 3. Stakeholder engagement and AMR projects

ESS10 provisions on stakeholder engagement and disclosure of information are essential elements of AMR projects that are shaped by actions in multiple sectors. ESS10 highlights the importance of open and transparent engagement between the client country and relevant stakeholders to improve the environmental and social sustainability of projects. Depending on the significance and context of the E&S risks and impacts, comprehensive analysis and design of the engagement process can involve independent third-party specialists. The type of stakeholders[51] who should be engaged as part of the assessment and management of E&S risks and impacts can vary significantly depending on the type of intervention (see Table 21).

Table 21. Examples of Possible Stakeholders by Sector

Type of stakeholder	Health: Improving prescribing guidelines for health care workers	Agriculture: Improving animal husbandry practice	WASH: Improving safe disposal of unused antimicrobials
Affected by project	Health care workers, patients, women's groups, pharmaceutical companies, pharmacies, etc.	Pastoralists, farmers, herders, women farmers, farmer groups, veterinarians, fish farmers, etc.	Health care workers, patients, women's groups, pharmaceutical companies, pharmacies, pastoralists, farmers, herders, women farmers, farmer groups, animal health workers, etc.
Interested in project	Patient organizations, youth, researchers, traders, nongovernmental organizations, civil society organizations	Community members, slaughterhouse workers, traders, faculties and students in veterinary colleges, women's groups, patient groups	Community members, animal welfare groups, nongovernmental organizations, civil society organizations, traders

Source: World Bank

Stakeholder engagement can help improve resonance and engagement with important actors from different sectors that are relevant to tackling AMR, in part by shaping messages and identifying gaps and entry points for AMR interventions. As resistant microorganisms can be transmitted through various pathways, such as person-to-person contact, person-to-animal contact, consumption of contaminated foods, and contact with human and agricultural wastes, projects addressing AMR will have a wide range of stakeholders who will be either directly or indirectly affected by both AMR and the interventions addressing AMR.

51 In accordance with ESS10, stakeholders are individuals and groups that are affected or likely to be affected by the project or may have an interest in the project (World Bank 2017).

Section 4. Guidance on actions for mitigation

Before project approval, the client country develops an ESCP that sets out the actions for mitigation that will enable the project to meet the ESSs over a specific time frame. The ESCP forms part of the legal agreement, and the client country is obligated to support the implementation of the ESCP.

AMR-informed projects can be better designed and monitored by referencing activities that positively impact the global stewardship of antimicrobials and measures that aim to systematically mitigate, adapt, and innovate regarding AMR. A good approach involves a combination of country or regional institutional support, such as a gap analysis regarding national standards or guidelines, legislation, or training, and promotion of good practices at HCF and livestock and aquaculture production facilities. Table 22 aims to support the capacity of project implementation units by providing examples of measures that can be included in the ESCP per relevant ESS and relating these to specific AMR interventions, measures, and actions.

Table 22. Material Measures and Actions for a Selection of AMR Interventions, by ESS

INTERVENTION TO ADDRESS AMR	MATERIAL MEASURE AND ACTION
ESS1: Assessment and Management of Environmental and Social Risks and Impacts	
• Improve the quality of veterinary medical products and their use under supervision by veterinarians • Improve antibiotic prescribing guidelines for health care workers • Strengthen surveillance of AMR and AMU in human populations	• Carry out a study to identify the project's impact on legitimate rights for land and natural resource tenure and use (including collective rights, subsidiary rights, and the rights of women) and other unintended consequences.
• Improve antibiotic prescribing guidelines for health care workers • Improve the quality of veterinary medical products and their use under supervision by veterinarians • Strengthen surveillance of AMR in human populations • Improve infection prevention and control	• Provide appropriate measures of protection and assistance, including training and capacity building, to ensure impacts of the project are equally distributed among all relevant groups and stakeholders, including vulnerable groups.
• Monitor sales and use of antimicrobials in animals • Strengthen surveillance of AMR and AMU in human populations and in animals, aquaculture, and crops • Detect and deter substandard and falsified antimicrobials	• Implement public and private standards for the registration, manufacture, distribution, sale, and use of antimicrobials throughout the supply chain.
ESS2: Labor and Working Conditions	
• Improve hand hygiene in health care settings • Increase human health laboratory capacity • Improve animal husbandry practice for livestock and aquaculture • Promote behavior change campaigns and the provision of alternatives in animal production • Increase veterinary laboratory capacity	• Provide appropriate measures of protection and assistance, including training, to address the vulnerabilities of project workers, including specific groups of workers such as women, people with disabilities, migrant workers, and children of working age.

INTERVENTION TO ADDRESS AMR	MATERIAL MEASURE AND ACTION
• Improve the quality of veterinary medical products and their use under supervision by veterinarians • Improve antibiotic prescribing guidelines for health care workers • Improve animal husbandry practice for livestock and aquaculture • Strengthen surveillance of AMR in human populations • Promote behavior change campaigns and the provision of alternatives in animal production • Increase veterinary laboratory capacity • Improve safe disposal of unused antimicrobials • Detect and deter falsified antimicrobials • Improve infection prevention and control	• Strengthen education, training, and communication at national and professional level in governing the use of antimicrobials
ESS3: Resource Efficiency and Pollution Prevention and Management	
• Improve hand hygiene in health care settings • Increase human health laboratory capacity • Improve infrastructure to provide access to water and sanitation in HCF, schools, and other facilities • Improve safe disposal of unused antimicrobials • Monitor antimicrobial use and antibiotic-resistant bacteria in water and sanitation systems • Use closed water systems in aquaculture	• Establish, operate, and maintain waste management systems adequate for the scale and type of activities and identified hazards.
• Improve infrastructure to provide access to water and sanitation in HCF, schools, and other facilities • Monitor antimicrobial use and antibiotic residues, resistant bacteria, and resistant genes in water and sanitation systems • Improve waste management practices in agriculture and aquaculture production/processing	• Carry out a wastewater composition analysis to identify wastewater treatment interventions.
ESS4: Community Health and Safety	
• Improve hand hygiene in health care settings • Increase human health laboratory capacity • Improve animal husbandry practice for livestock and aquaculture • Improve infrastructure to provide access to water and sanitation in HCF, schools, and other facilities • Monitor antimicrobial use and antibiotic-resistant bacteria in water and sanitation systems • Improve waste management practices in agriculture and aquaculture production/processing • Improve human and animal nutrition • Use closed water systems in aquaculture • Expand vaccine coverage	• Carry out a study on community exposure to diseases that could result from project activities (including waterborne, water-based, water-related, and vector-borne diseases and both communicable and noncommunicable diseases), taking into consideration differentiated exposure and higher sensitivity of vulnerable groups to identify interventions.

INTERVENTION TO ADDRESS AMR	MATERIAL MEASURE AND ACTION
• Improve hand-hygiene in health care settings • Improve antibiotic prescribing guidelines for health care workers • Conduct public awareness campaigns • Improve the quality of veterinary medical products and their use under supervision by veterinarians • Improve animal husbandry practice for livestock and aquaculture • Strengthen surveillance of AMR in human populations • Promote behavior change campaigns and the provision of alternatives in animal production • Improve safe disposal of unused antimicrobials • Improve waste management practices in agriculture and aquaculture production/processing • Improve infection prevention and control • Expand vaccination coverage • Improve human and animal nutrition	
• Improve animal husbandry practice for livestock and aquaculture	• Implement and maintain adequate disinfection and sterilization procedures and facilities.
ESS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources	
• Improve the quality of veterinary medical products and their use under supervision by veterinarians • Improve animal husbandry practice for livestock and aquaculture • Improve human and animal nutrition	• Develop an action plan for how livestock and fish farmers can transition away from reliance on antimicrobials through good animal health practices and biosecurity measures.
• Improve the quality of veterinary medical products and their use under supervision by veterinarians • Improve animal husbandry practice for livestock and aquaculture • Promote behavior change campaigns and the provision of alternatives in animal production • Improve safe disposal of unused antimicrobials. • Use closed water systems in aquaculture • Improve human and animal nutrition • Expand vaccine coverage	• Carry out a study to identify production systems that are heavily reliant on drugs and critical points in animal life cycles where the use of antimicrobials is highest.
• Improve infrastructure to provide access to water and sanitation in HCF, schools, and other facilities • Improve wastewater management practices in aquaculture production and processing • Monitor antimicrobial use and antibiotic-resistant bacteria in water and sanitation systems • Use closed water systems in aquaculture	• Establish water systems to reduce wastewater pollution.

INTERVENTION TO ADDRESS AMR	MATERIAL MEASURE AND ACTION
ESS10: Stakeholder Engagement and Information Disclosure	
All interventions but the following in particular: • Conduct public awareness campaigns • Improve animal husbandry practice for livestock and aquaculture • Promote behavior change campaigns and the provision of alternatives in animal production	• Identify the disadvantaged or vulnerable. • Describe in the Stakeholder Engagement Plan what measures will be used to remove obstacles to participation, and how the views of differently affected groups will be captured. Where applicable, include differentiated measures in the plan to allow the effective participation of the disadvantaged or vulnerable. • Provide stakeholders with access to information on potential risks and impacts that might disproportionately affect the vulnerable and disadvantaged, and describe the differentiated measures taken to avoid and minimize these. • Disclose information in relevant local languages and in a manner that is accessible and culturally appropriate, taking into account any specific needs of groups that may be differentially or disproportionately affected by the project or groups of the population with specific information needs (e.g., related to disability, literacy, gender, mobility, differences in language, or accessibility).

Source: World Bank.

Note: AMU = antimicrobial use; ESS = Environmental and Social Standard; HCF = health care facilities.

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