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Mitigation of Antimicrobial Resistance (AMR) in G20

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Abstract

Antimicrobial resistance (AMR) is a recognised global threat to health security. However, mainstreaming responses to this threat into public policy has remained elusive, and anti-AMR measures have been limited to health interventions. AMR is caused by global factors, including sustained and irresponsible antibiotic use in humans and animals, as well as climate change. Hence its effective management also requires global collaborative efforts. This policy brief provides an overview of AMR, its significance, and the current landscape of policies, national action plans, and funding for AMR research and surveillance within the G20 countries. It also highlights the need for concerted action and international cooperation to address this critical issue.

Keywords: Antimicrobial resistance, G20, Pandemic, NAPs

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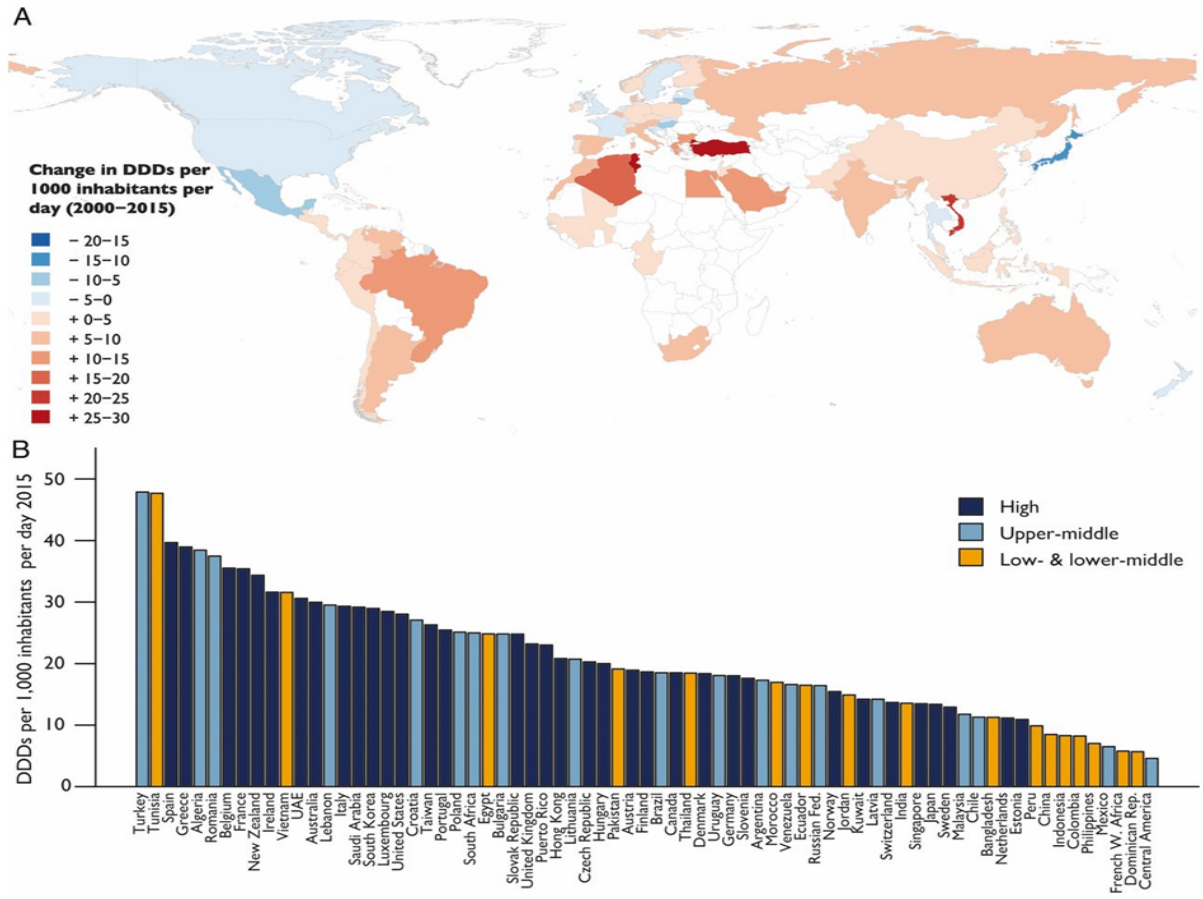
1. Introduction

Antimicrobial resistance (AMR) refers to the ability of microorganisms, including bacteria, viruses, fungi, and parasites, to withstand the effects of antimicrobial drugs, rendering them ineffective in treating infections. This can aggravate illness, leading to disability or death in cases where such extreme consequences were once preventable through medication. This phenomenon, which arises as pathogens evolve to escape drugs, is exacerbated by the misuse of antimicrobial agents in human healthcare and animal agriculture. AMR undermines the effectiveness of existing treatments, leading to increased morbidity, mortality, and healthcare costs, as well as compromising the success of surgeries, transplants, and cancer chemotherapy.

The emergence of AMR can be traced back to the 1940s, shortly after the widespread use of penicillin began (Review on Antimicrobial Resistance, 20161). Since then, AMR has grown into a serious global health threat. It is estimated that AMR causes 700,000 deaths yearly, which is expected to rise to 10 million deaths by 2050. The economic cost of AMR is also significant, estimated to be $100 billion per year (Review on Antimicrobial Resistance, 2014). The World Bank estimates that by 2050, AMR could cause global economic damage equivalent to the shocks experienced during the 2008 financial crisis, with an annual GDP loss of 3.8 per cent (World Bank, 2017).

A causal factor for AMR is indiscriminate antibiotic use. Analysing the global trends in antibiotic use, it is evident that there is a significant geographical disparity. In high-income countries, such as those in North America and Western Europe, there has been a concerted effort to curb the overuse of antibiotics, leading to a relative decrease in their consumption (Figure 1). This is largely due to increased awareness of the risks of antibiotic resistance, and the implementation of stringent antibiotic stewardship programs. However, in many low to middle-income countries (LMIC), there has been a 65% increase in antibiotic use between 2000 and 2015. Among G20 countries, Turkiye and Brazil have seen the largest increase in consumption (Klein et al., 2018).

Figure 1: Change in Defined Daily Dose (DDD) of antibiotics per 1000 inhabitants per day (2000-2015)



Adapted from (Klein et al., 2018). DDD is the assumed average maintenance dose per day for a drug used for its main indication in adults.

This rise is attributed to factors such as population growth, economic development, increased access to medicines, the prevalence of infectious diseases, and lack of regulation in antibiotic sales. The lack of stringent regulatory mechanisms and easy availability of antibiotics has led to their overuse. The WHO's 2021 report emphasises that escalated antibiotic consumption in Low-and-Middle Income Countries (LMICs) is leading to the proliferation of antibiotic-resistant bacteria (World Health Organisation, 2021a). This not only jeopardizes the health of populations in these countries, but also has far-reaching global consequences, due to the spread of resistant strains.

Broad-spectrum antibiotics such as cephalosporins, fluoroquinolones, and carbapenems are among the most consumed in LMICs (Klein et al., 2018). These antibiotics are known for their ability to target a wide range of bacteria. Moreover, there is a significant consumption of over-the-counter antibiotics, without prescriptions, including amoxicillin, tetracyclines, and trimethoprim/sulfamethoxazole combinations (Morgan et al., 2011).

The rampant use of antibiotics has resulted in several pathogens developing resistance. These include:

- Klebsiella pneumoniae - This bacterium associated with pneumonia in patient populations with alcohol use disorder or diabetes mellitus has developed resistance to carbapenems, which are considered last-resort antibiotics for treating severe infections (Nordmann and Poirel, 2014).

- Escherichia coli (*E. coli*) - An increasing number of *E. coli* strains have become resistant to commonly used antibiotics, leading to complications in treating infections such as urinary tract infections (Tacconelli et al., 2017).

- Staphylococcus aureus - Methicillin-resistant Staphylococcus aureus (MRSA) is a well-known antibiotic-resistant bacterium, which is difficult to treat and is a cause for concern in hospital settings, particulary for wound care (Chambers and DeLeo, 2009).

- Mycobacterium tuberculosis (MDR-TB and XDR-TB) - Multi-drug resistant (MDR) and extensively drug-resistant (XDR) tuberculosis are forms of tuberculosis that are resistant to at least the two main first-line drugs (Seung et al., 2015).

- Neisseria gonorrhoeae - This bacterium, which causes gonorrhea, has developed resistance to a large number of antibiotics and is now termed as a “superbug” due to its ability to evade multiple drugs (Unemo and Shafer, 2014).

The World Health Organisation (WHO) has identified a list of priority microbes (Appendix 1), that are considered to pose the greatest threat to human health due to antimicrobial resistance (AMR). However, even the WHO priority microbes list is not exhaustive, and other microbes that pose a threat to human health due to AMR may exist.

The global nature of AMR evolution demands a global response for its mitigation. No single country or groups of country can effectively mitigate the rise and spread of AMR pathogens. Hence, the WHO has become a nodal agency in the global response to AMR.

2. Global actions against AMR

2.1 World Health Organisation's Global Action Plan

The WHO has developed the Global Action Plan (GAP) on Antimicrobial Resistance, which serves as a comprehensive framework for addressing AMR at the global, regional, and national levels (World Health Organisation, 2021b).

The action plan is built on five strategic pillars, aiming to:

- Enhance awareness and understanding of AMR through effective communication, education, and training.
- Strengthen knowledge and evidence base through surveillance and research.
- Reduce the incidence of infection through sanitation, hygiene, and infection prevention measures.
- Optimise the use of antimicrobial medicines in human and animal health.
- Develop an economic case for sustainable investment and increase investment in new medicines, diagnostic tools, vaccines, and other interventions.

A salient feature of this plan is the adoption of the **One Health approach**, which is an integrative effort of multiple disciplines working locally, nationally, and globally to attain optimal health for people, animals, and the environment. This approach is indispensable given the intricate interconnectedness of human, animal, and environmental health.

2.2 WHO's GLASS initiative:

The WHO Global Antimicrobial Resistance Surveillance System (GLASS) operates as an integral component of the WHO-GAP. GLASS bolsters the second strategic objective of GAP, fortifying the knowledge base through robust surveillance. This enables a data-driven approach in understanding the magnitude of AMR, and facilitates informed decision-making for national and global interventions.

GLASS was launched in 2015 to boost AMR surveillance and inform strategies to contain AMR. The system started with surveillance of AMR in bacteria causing common human infections, and has expanded its scope to include surveillance of antimicrobial consumption (AMC), invasive fungal infections, and a One Health surveillance model relevant to human health. By the end of 2022, GLASS incorporated data from 127 countries, territories, and areas (World Health Organisation, 2022).

2.3 The Quadripartite

The Quadripartite Collaboration for One Health coordinates joint One Health work through global activities addressing health risks at the human-animal-food-plant-environment interfaces (FAO et al., 2022). The organisations in this collaboration are the Food and Agriculture Organization of the United Nations (FAO), the United Nations Environment Programme (UNEP), the World Health Organization (WHO), and the World Organisation for Animal Health (WOAH).

2.4 Pandemic Treaty

The pandemic treaty is a currently-under-discussion international agreement to build capacity and guide countries in the event of a public health emergency. The initial draft of the pandemic treaty did not dwell on AMR. However, after significant lobbying from public health experts and civil society organisations, AMR was included in the most recent draft (Lindsay et al., 2021).

The revised version includes a number of provisions related to AMR, including

- The need to strengthen surveillance and monitoring of AMR.
- The need to promote the rational use of antimicrobials.
- The need to develop and implement national action plans to address AMR.

However, some experts have argued that the revised treaty does not go far enough to address AMR. They have called for the treaty to include specific commitments to:

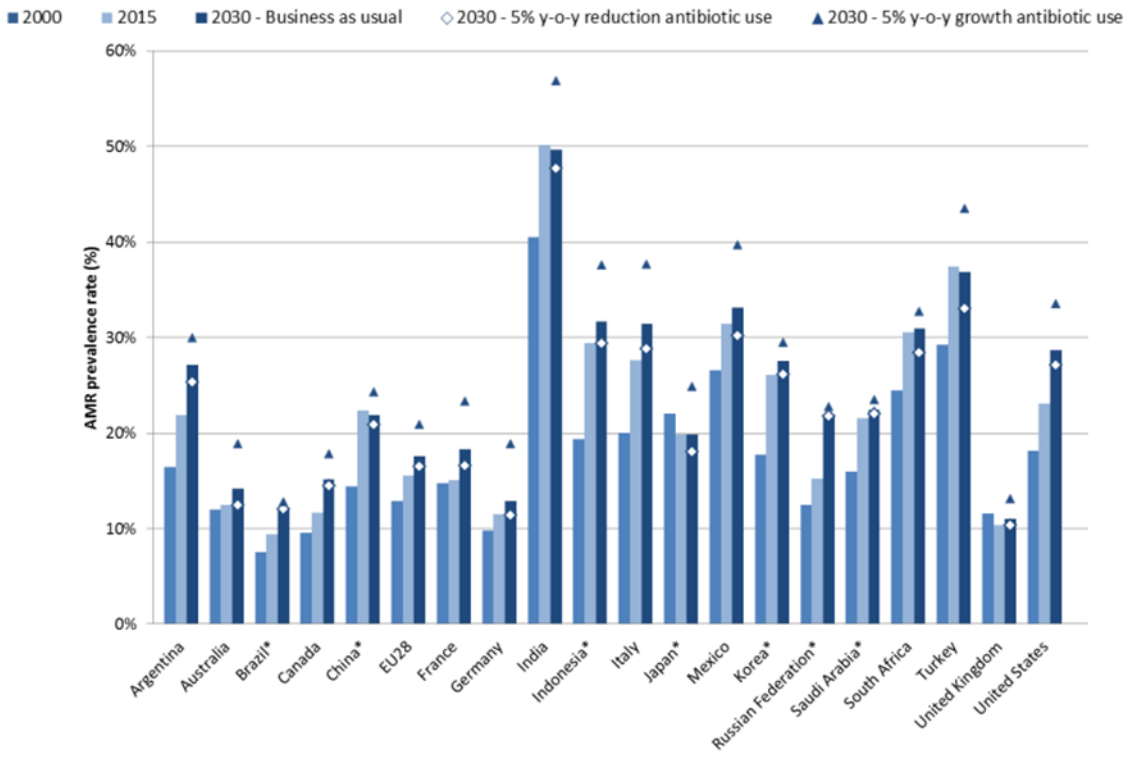
- Investing in research and development of new antimicrobials.
- Enhancing access to existing antimicrobials.
- Addressing the drivers of AMR, such as the use of antimicrobials in agriculture.

While global action is necessary, forums such as WHO may not be able to rapidly drive change to keep pace with the development of AMR. Smaller forums, which represent global interests and have enough resources to guide action, are ideal platforms to take action against AMR. The G20 thus lends itself to be a necessary player in the fight to prevent spread of AMR.

3. Role of G20

The G20 is a collective of the world's largest economies, with an 85% share of the global economy and 65% share of the global population. The G20 countries also house a significant share of the global AMR burden, which is expected to grow unless the use of antibiotics is reined in (Figure 2). At the G20 health track meetings, where discussions can influence global health and economic policies, taking action on AMR is not only a matter of global health security but also a question of economic sustainability and stability. By investing in robust surveillance and monitoring systems, facilitating equitable access to vaccines, therapeutics, and diagnostic tools, and fostering international cooperation and collaboration, G20 nations can significantly contribute to the containment of AMR. These actions can lead to better health outcomes, a more resilient global health infrastructure, and a stronger, more sustainable global economy, thereby creating a far-reaching positive impact.

Figure 2: AMR prevalence rates in G20 countries



Source: (OECD et al., 2017)

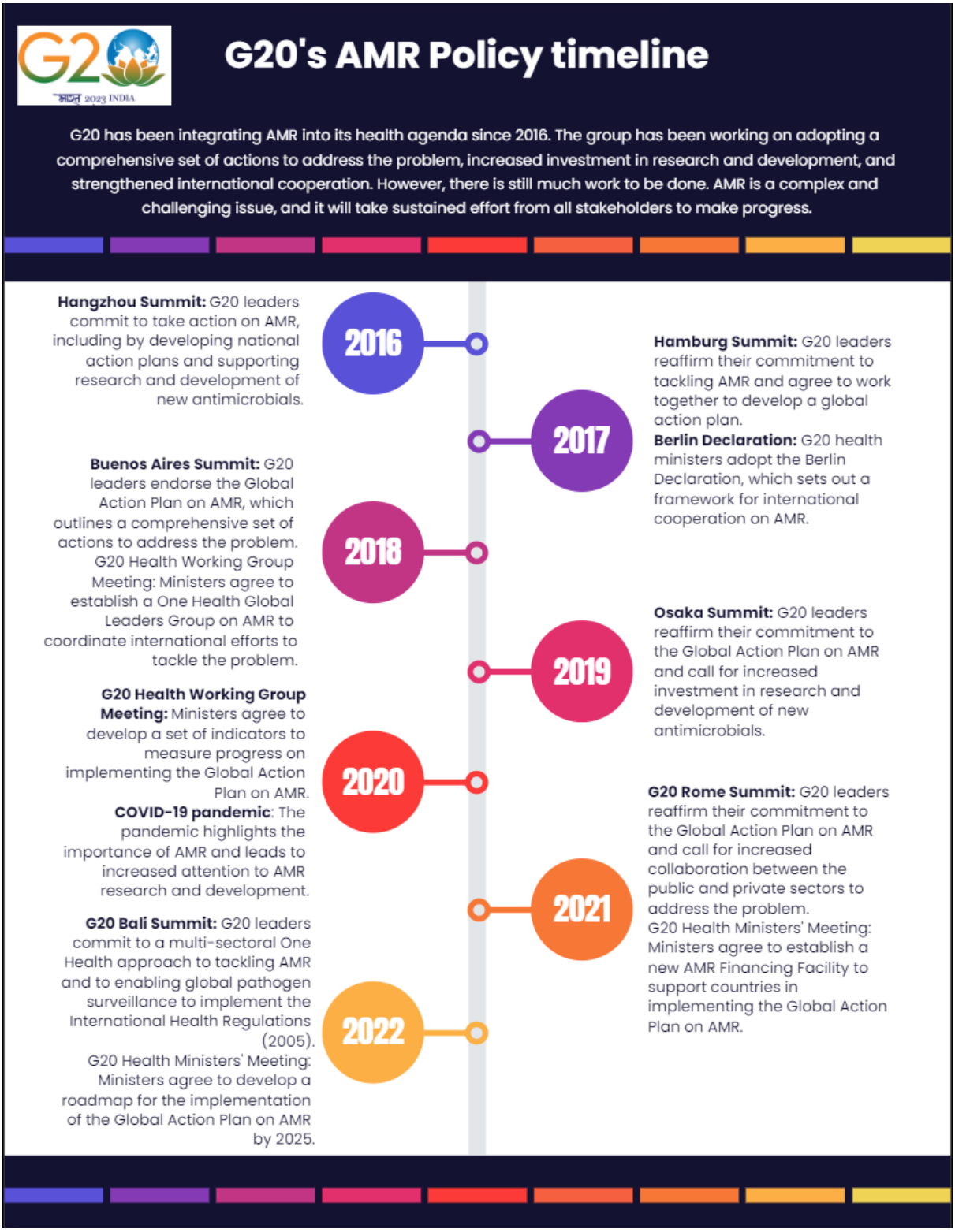
3.1 Previous actions of G20 pertaining to AMR

The G20 has recognised AMR as a major challenge, integrating it into its agenda as a key health priority to ensure global health security and economic stability.

- The issue of AMR was introduced as a key issue in the 2016 Hangzhou Summit,
- The 2017 Hamburg Summit resolved to maximise the impact of existing and new antimicrobial basic and clinical research initiatives, as well as of product development (G20 Leaders Declaration, 2017).
- In 2018, the G20 adopted its Action Plan on Antimicrobial Resistance at Buenos Aires. This plan recognised the global public health threats posed by AMR, and acknowledged the urgency of addressing this issue. It also acknowledged the disproportionate impact of AMR on LMICs, which often lack sufficient resources for healthcare services, quality medicines, surveillance programs, waste management systems, and wastewater treatment.
- The 2022 Bali Summit further committed to a multi-sectoral One Health approach and to enable global pathogen surveillance to implement the International Health Regulations (G20 Leaders Declaration, 2020).

The COVID-19 pandemic has disrupted AMR governance, and increased inequality of access to healthcare and essential medicines in LMICs. The G20 aims to ensure that investments in the COVID-19 response enhance national capacity to respond effectively to AMR.

Figure 3: A timeline of G20 commitments on AMR.



Source: Compiled by the authors.

To address the AMR threat, the G20 has emphasised the need for global surveillance and monitoring of humans, animals, plants, food, and the environment. It has urged countries to join GLASS and participate in regional AMR surveillance networks. It has also highlighted the necessity

of the Quadripartite platform for linking and referring to current initiatives for AMR and AMU surveillance data across sectors. The SECURE initiative is a new G20 commitment to expanding sustainable access to antibiotics by improving surveillance of AMR, promoting the rational use of antibiotics, and investing in research and development of new antibiotics (World Health Organisation, n.d.)

The G20 has also called for scaling up collaborative, coordinated, One Health AMR surveillance, risk assessment, and interventions. It recommends that countries strengthen AMR surveillance across humans, animals and environment through improved use of local data. It also suggests focusing on prevention-oriented actions, and supporting LMICs to mitigate the risks posed by AMR (FAO et al., 2022). It encourages countries to monitor the WHO priority microbes, including but not limited to Escherichia coli and methicillin-resistant Staphylococcus aureus (MRSA), and other nationally-determined priority pathogens.

The G20 aims to increase equitable access to vaccines, therapeutics, diagnostic tools (VTDs), and innovative preventive tools, to prevent and control infections in humans, plants, and animals. It emphasises the importance of responsible and prudent use of antimicrobials in all settings. It also recognises the need to enhance global efforts to increase the availability of new and existing VTDs for human and animal health.

Of the multiple regional governance initiatives in which G20 countries participate, only 4 do not have a policy or declaration regarding AMR. (Appendix 2) Although the G20's commitments are significant, implementation and funding have to be more consistent, under the guidance of a unified international framework (Clift, 2019).

In the next sections, we analyse individual national action plans and their implementation by G20 countries.

3.2 Common Policies and National Action Plans of G20 Countries

National Action Plans (NAP) serve as comprehensive frameworks that guide countries in coordinating and implementing measures to combat antimicrobial resistance. The G20 countries have developed their NAPs based on WHO GAP objectives. NAPs facilitate the engagement of multiple stakeholders, including the government, healthcare professionals, the agricultural sector, and the public, which is crucial given the multifaceted nature of AMR. Given the evolving nature of AMR, NAPs are time-bound, and need to be periodically revised to update strategies. Although all G20 countries have created NAPs, only China, France, Indonesia, the Republic of Korea, South Africa, the USA, Belgium, Ireland, Malta, Portugal, Slovenia, and Sweden have active NAPs as of 2023. There is an urgent need for the other countries to update and renew their NAPs.

All NAPs have recurring themes, which are based on the WHO GAP's objectives. These include strategies for promoting responsible antimicrobial use, strengthening surveillance systems, enhancing infection prevention and control practices, and fostering research and development of new

antimicrobials and alternative treatments. Some plans are, however, more detailed, with defined calls to action and targets.

For example, The UK's National Action Plan on AMR (2019-2024) adopts a "One Health" approach, encompassing humans, animals, and the environment. One of its highlights is the laying out of precise targets: to reduce antibiotic use in humans by 15% and in animals by 25% by 2024. The UK's plan also emphasises global leadership, with commitments to support other countries in enhancing their AMR surveillance and stewardship programs. It discusses funding for AMR research, including models such as imposing an antibiotic investment charge on the pharmaceutical sector in a pay or play model. It also presents a detailed AMR systems map, outlining causes of AMR in various settings. The plan is part of the UK's 20-year plan on tackling AMR, which shows their foresight in understanding and attempting to mitigate the development of AMR (HM Government, 2019).

Sharing best practices and collaborating on common goals within the G20 framework can foster knowledge exchange and drive progress in AMR management. Analysis of individual NAPs shows special features in select NAPs, which may be of utility to other countries.

Table 1: Special features of the NAPs of individual G20 countries.

Countries	Special Features	Analysis
Argentina	Encourages innovation in antimicrobials, non-antibiotic growth promoters, and diagnostic tests for the identification and characterization of resistant bacteria.	This NAP recognises the use of antibiotics in animal husbandry as a growth promoter and not only as an antimicrobial agent. It recognises that substituting the growth promoting function of antibiotics will be essential for their replacement in this vertical.
Canada	Increase effective implementation of infection prevention measures, particularly for populations disproportionately impacted by AMR, such as remote, Northern, and isolated communities.	The Canada NAP recognises that certain sub-populations, particularly those living in crowded areas or with restricted healthcare access, are disproportionately impacted by AMR and require additional support.

China	Establish an appropriate clinical antimicrobial drug sensitivity breakpoint standard system [2]for China. Develop and promote the use of safe, efficient, and low-residue veterinary traditional Chinese medicine.	China aims to contextualise AMR measures to local conditions, and create an appropriate technical guideline for AMR in China. The NAP also seeks to study the use of traditional Chinese medicine as an alternative to the use of antibiotics.
Germany	To reduce the transmission of resistant bacteria along the food chain, the policy includes consistently pursuing successful control programs for salmonella in poultry farming, further developing the concept of process hygiene criteria for food production, and expanding these to cover the border aspect of resistance problems. Transferring certified professional development programs to experts in antibiotic prescription (ABS officers) in a structured Curricular Advanced Training Programme of the chambers of physicians.	The German NAP highlights the importance of studying AMR in food chains. As part of their strategy, the German NAP has also created a structured training programme, which is a pre-requisite for becoming an antibiotic stewardship appointee or expert at a hospital or clinic.
India	Focuses on the importance of developing new vaccines and diagnostics for AMR. Developing Infection Prevention Control (IPC) standards for each level of healthcare facility, not just tertiary care centres. Establishing functional hospital infection control committees (HICCs) to provide leadership to the IPC programs at the institutional level.	India's plan calls for the development of vaccines as a substitute for antibiotics. It also recognises the need to maintain standards at all healthcare settings, not only tertiary hospitals.

Indonesia	Includes specific section on the importance of improving sanitation and hygiene.	Indonesia recognises the importance of improving basic hygiene as a part of the long-term plan to avoid infections and consequently, AMR.
Italy	Electronic prescribing systems.	The Italian NAP proposes the use of electronic prescribing systems as a method to monitor and regulate antibiotic use.
Japan	Tax incentives for pharmaceutical companies and funding for research institutions.	Japan, which has a long history of producing novel antibiotics, provides for tax incentives for companies to research alternatives to antibiotics.
Mexico	Unique initiative is the "Antibiotic Guardians" campaign, which aims to raise public awareness about the risks associated with AMR and promote responsible use of antibiotics. The campaign encourages individuals to take a pledge to become an "Antibiotic Guardian" by committing to use antibiotics only when necessary and as prescribed by a healthcare professional.	Mexico has an outlined awareness campaign, co-opting individuals to become Antibiotic Guardians.
South Korea	Includes a specific section on the importance of developing new economic models for the sustainable development of antibiotics.	South Korea recognises the need for new economic models for incentivising development of antibiotics.
United States	Focus on data infrastructure, and assistance to LMICs.	This NAP recognises the need to address data asymmetry to control AMR, and to address disparities in health infrastructure between the US and LMICs.

Austria	Conducting health literacy survey of population.	Austria's NAP recognises the need to understand health literacy as a first step to running successful awareness campaigns.
United Kingdom	Targets to: Halve healthcare associated Gram-negative blood stream infections; Reduce the number of specific drug-resistant infections in people by 10% by 2025; Reduce UK antimicrobial use in humans by 15% by 2024; Reduce UK antibiotic use in food-producing animals by 25% between 2016 and 2020 and define new objectives by 2021 for 2025; and Be able to report on the percentage of prescriptions supported by a diagnostic test or decision support tool by 2024.	United Kingdom outlines specific targets to achieve with respect to reduction of infections in humans and animals.
Belgium	Reducing environmental contamination with antimicrobials and resistant bacteria.	This NAP highlights the need to curb the release of antibiotics into the environment.
Ireland	The CellCheck program Optimising feedback of computerized meat inspection findings and Precision Livestock Farming monitors on farm to improve pig health.	Ireland rationalises the use of antibiotics in the animal sector, promoting other methods to improve health of animals and thereby, lowering antibiotic use.

Denmark	The number of redeemed prescriptions for antibiotics in the primary healthcare sector should be reduced from 460 prescriptions per 1000 inhabitants per year in 2016 to 350 prescriptions per 1000 inhabitants per year in 2020. There should be a change in the use of broad-spectrum to narrow-spectrum antibiotics. Consumption of antibiotics that are critically important for the treatment of infections should be reduced.	The Danish NAP also recommends specific targets for reducing antibiotic use, and a move from broad-spectrum to narrow-spectrum antibiotics to reduce AMR risk. The NAP has specific targets for other parameters related to AMR, such as proportion of Penicillin prescribed, or rational use of antibiotics in hospitals. In contrast to other targets, Denmark achieved its goal of reducing prescriptions by 2020 (Lundsby and Sönksen, n.d.).
Slovakia	Focus on increasing the national production of raw materials of animal origin due to the risk of importing unknown bacteria with genetically determined antibacterial resistance and risk to public health.	This NAP looks at ways to reduce import produce and thereby reduce the risk of importing AMR bacteria.

3.4 Implementation of NAPs across G20 countries

Most G20 countries have a national action plan on AMR, but there is a wide variation in the level of implementation. Various studies have found that highly developed nations have more detailed and better implemented plans than LMICs (Charani et al., 2023; Willemsen et al., 2022; Patel et al., 2023). For example, Australia, Canada, and France have fully implemented their national action plans, while Argentina, Brazil, and India have only partially implemented their plans (Munkholm and Rubin, 2020).

There is a lack of coordination between different sectors in addressing AMR in some G20 countries. For example, in Argentina, the Ministry of Health is responsible for developing the national action plan on AMR, but the Ministry of Agriculture is responsible for implementing the plan. This lack of coordination can make it difficult to develop and implement effective policies and interventions.

4. Funding for AMR Research and Surveillance

There is a need for more investment in research and development of new antimicrobials in all G20 countries. The current pipeline of new antimicrobials is not sufficient to meet the challenges of AMR. Sufficient funding is crucial to drive research, surveillance, and implementation of AMR-related initiatives. However, the funding for AMR varies across G20 countries.

In 2021, the United States was the largest investor in AMR R&D, with an estimated investment of $4.5 billion. China was the second largest investor, with an estimated investment of $3.5 billion. Japan, Germany, and the United Kingdom were also significant investors, with estimated investments of $2.5 billion, $2 billion, and $1.5 billion, respectively. Other G20 countries invested significantly less in AMR R&D. For example, India invested an estimated $0.5 billion, and Russia invested an estimated $0.2 billion. Appendix 3 lists research spending on AMR for all the G20 countries.

The investment landscape for AMR R&D is growing, but it is still not enough. In 2021, there was an estimated $8.9 billion invested in AMR R&D, up from $7.2 billion in 2020. However, this is still far below the $10 billion per year that is estimated to be needed to address the AMR crisis (Global AMR R&D Hub, 2021).

There is a need for more investment in neglected areas of AMR R&D. Some areas of AMR R&D, such as the development of new diagnostics and vaccines, are still under-funded.

5. Recommendations for G20

As the President of the G20 in 2023, India has a crucial role to play in addressing AMR within the G20 framework. India's leadership can provide an opportunity to emphasise the importance of AMR management and strengthen collaboration among G20 countries. Here are some key areas which can be highlighted:

1) Advocacy and Awareness: India can actively advocate for AMR as a priority agenda item during the G20 Health Track discussions by:

- Setting up a permanent taskforce and secretariat to ensure continual commitment and preserve institutional memory on G20 efforts. The functioning of this taskforce can be based on the Northern Dimension Partnership in Public Health and Social Well-Being, a cooperation platform of ten partner countries and several international organizations, including the WHO and the European Commission, which operates on different levels, including activities such as high-level ministerial dialogues and an extensive network of experts (Northern Dimension Partnership in Public Health and Social Well-Being, n.d.).
- Working with other G20 countries to develop a joint statement on AMR, which should set a global AMR reduction target by a pre-defined date.

- Championing an international funding mechanism, taking cues from the Global Fund, that focuses on AMR R&D. India can host a pledging conference, inviting G20 and other nations to contribute to this dedicated fund.
- Launching AMR Awareness Campaign with Cultural Sensitivity: Building on India's extensive experience in public health campaigns, such as Polio and Swachh Bharat, create a template for an international AMR awareness campaign, incorporating cultural and linguistic diversity for global reach and efficacy (World Health Organisation, 2017).
- Initiating Global Antimicrobial Stewardship Program: Learning from the successful implementation of the Antimicrobial Stewardship Program in Kerala, India can promote a globalised version of this initiative within G20, with adaptable frameworks for different healthcare settings (Government of Kerala, 2018).
- Advocating for changing prescribing practices: Doctors and other healthcare providers should prescribe antibiotics only when necessary, and for the shortest possible duration. For this, introduce the Antimicrobial Stewardship Programs (ASP), similar to the CDC's Core Elements, to improve antibiotic prescribing. Implement regular training and auditing for healthcare providers to ensure adherence to the protocols.Follow electronic prescription system as outlined in the Italian NAP.
- Launching Public Education Campaigns on AMR: Utilise the 'e-Bug' program model, developed by Public Health England, which successfully engages schools and communities through educational resources, to raise awareness about the responsible use of antibiotics (Public Health Agency, n.d.).
- Developing innovative measures to ensure dosage completion: AMR risk is high when patients suffering from microbial infections do not finish their recommended dosages. This creates an opportunity for pathogens to be exposed to low doses of the antibiotic and developing mechanisms of resistance. The G20 can hold competitions to devise awareness campaigns, novel packaging methods, incentive structures etc. to increase patient compliance.

2) Collaboration and Research:

The G20 can

- Establish a G20 AMR Innovation Challenge: India can initiate an AMR Innovation Challenge within the G20, modelled after the iGEM to promote the development of new antimicrobials, diagnostics, and vaccines (iGEM, n.d.).
- Work with developing countries to develop regional AMR action plans
- Foster international research on alternative AMR Therapies: Facilitate smaller multilateral groups of countries to foster international research collaborations on alternative AMR therapies.

- Increase investment in AMR R&D: This investment should be directed towards early-stage research, neglected areas of AMR R&D, and international collaboration.
- Share best practices for incentivising research: AMR research requires innovative funding mechanisms. The US has proposed the Pasteur Act to incentivise companies to conduct AMR research, but more innovative methods led by multi-government front might be required.
    - Adopt the 'Innovative Medicines Initiative' model, a European public-private partnership that encourages pharmaceutical innovation, for fostering an ecosystem of antimicrobial innovation (Innovative Medicines Initiative, n.d.).
    - Adopt the "Priority Review Voucher" program, similar to what has been successfully implemented by the FDA in the US, to incentivize pharmaceutical companies for antibiotic development.
    - Simultaneously, employ the "Health Impact Fund" model to establish pricing that balances company ROI with patient affordability (United States Government, 2020).
- Establish an AMR-focused counterpart to the Coalition for Epidemic Preparedness Innovations (CEPI) to expedite research and development of vaccines and diagnostics and facilitate collaborations between public and private sectors.

3) Capacity Building for better surveillance and management of AMR

- All G20 countries should sign up to GLASS, to report data on both AMR and antibiotic consumption. Currently, most countries participate in GLASS for AMR data, but several of the G20 countries do not capture or share data on antibiotic consumption (Appendix 4).
- Provide technical assistance to developing countries in the areas of AMR surveillance, prevention, and treatment.
- Encourage addressing social determinants in AMR Policies: Utilising the experience of Indian NGOs in addressing social determinants of health, India can encourage the G20 to incorporate social determinants into AMR strategies, fostering policies and programs that are more inclusive and holistic. G20 countries should implement the Social Determinants of Health Framework by the WHO to holistically address poverty, inequality, and healthcare access in AMR policies (World Health Organisation 2022b).
- Build AMR surveillance capacity in low-income Countries: Taking inspiration from India's capacity-building efforts such as the Indian Technical and Economic Cooperation, India can spearhead a G20 initiative focusing on capacity-building in AMR surveillance and laboratory infrastructure in low-income countries (The Indian Technical and Economic Cooperation Programme, n.d.).

    - G20 countries can utilise the "Fleming Fund" model, which has been successfully implemented in the UK to help low and middle-income countries to strengthen their AMR surveillance and laboratory capacity (The Fleming Fund, n.d.).
- Promote South-South cooperation for patent reforms: Facilitate dialogue among developing countries to explore models like the Medicines Patent Pool, which has been successful in promoting access to HIV medications, for fostering innovation and ensuring affordability in the realm of new antibiotics (Medicines Patent Pool, n.d.).

As the President of G20 2023, India can play a pivotal role in advancing the agenda on AMR. By advocating for AMR as a global health priority, sharing knowledge and experiences, fostering collaboration, and promoting sustainable financing, India can contribute to a coordinated and comprehensive response to AMR within the G20 countries and beyond.

Appendix

Table 2: List of priority pathogens as identified by WHO[3]

Name of Bacteria	Priority	Resistance Pattern
Acinetobacter baumannii	Critical	Carbapenem-resistant
Pseudomonas aeruginosa	Critical	Carbapenem-resistant
Enterobacteriaceae	Critical	Carbapenem-resistant, ESBL-producing
Enterococcus faecium	High	Vancomycin-resistant
Staphylococcus aureus	High	Methicillin-resistant, vancomycin-intermediate and resistant
Helicobacter pylori	High	Clarithromycin-resistant
Campylobacter spp.	High	Fluoroquinolone-resistant
Salmonellae	High	Fluoroquinolone-resistant
Neisseria gonorrhoeae	High	Cephalosporin-resistant, fluoroquinolone-resistant
Streptococcus pneumoniae	Medium	Penicillin-non-susceptible
Haemophilus influenzae	Medium	Ampicillin-resistant
Shigella spp.	Medium	Fluoroquinolone-resistant

Table 3: List of G20 countries with the Start and end year for their existing NAP

Countries	Start year	End year
Argentina	2015	-
Australia	2020	-
Brazil	2017	2021
Canada	2015	2021
China	2022	2025
France	2022	2025
India	2017	2021
Indonesia	2020	2024
Italy	2017	2020
Germany	2020	-
Japan	2016	2020

Mexico	2018	-
Republic of Korea	2021	2025
Russian Federation	2017	-
Saudi Arabia	2017	2018
South Africa	2018	2024
Turkey	-	-
United Kingdom of Great Britain and Northern Ireland (the)	2017	2020
United States of America	2020	2025
European Union		
Austria	2021	-
Belgium	2020	2024
Bulgaria	-	-
Croatia	2017	2021
Cyprus	2012	
Czech Republic (the)	2019	2022
Denmark	2017	2020
Estonia	-	-
Finland	2017	2021
Greece	2008	2012
Hungary	-	-
Ireland	2021	2025
Latvia	2019	2020
Lithuania	2017	2021
Luxembourg	2018	2022
Malta	2020	2028
Netherlands	2015	-
Poland	2016	2020
Portugal	2019	2023
Romania	-	-
Slovakia	2019	2021
Slovenia	2019	2024
Spain	2019	2021
Sweden	2020	2023

Table 4: Smaller groupings with participation of G20 countries and their AMR declaration status

Initiative	Countries	AMR Policy/ Declaration
APEC	Australia, China, Japan, South Korea, Indonesia, Mexico, Russia, and the United States	Yes
ASEAN	Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam	Yes
BRICS	Brazil, China, India, Russia, and South Africa	Yes
EU	France, Germany, Italy, and the United Kingdom	Yes
GCC	Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates	Yes
G7	Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States	Yes
NAFTA	Canada, Mexico, and the United States	Yes
Organisation of Islamic Cooperation (OIC)	57 countries including Indonesia and Saudi Arabia	Yes
SAARC	Bangladesh, Bhutan, **India**, Nepal, the Maldives, Pakistan, Sri Lanka, and Afghanistan	Yes
UNASUR	**Argentina**, Bolivia, **Brazil**, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, and Venezuela	Yes
African Union (AU)	55 African countries including South Africa	Yes
Arab League	22 countries including Saudi Arabia	No
Gulf Cooperation Council (GCC)	6 countries: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, UAE	No
Southern African Development Community (SADC)	16 countries including South Africa	No
Organization of American States (OAS)	35 countries: All 35 independent states of the Americas	Yes

Eurasian Economic Union (EAEU)	5 countries: Armenia, Belarus, Kazakhstan, Kyrgyzstan, Russia	No
Shanghai Cooperation Organisation (SCO)	8 countries: China, India, Kazakhstan, Kyrgyzstan, Pakistan, Russia, Tajikistan, Uzbekistan	No
Mercado Común del Sur (MERCOSUR)	4 countries: Argentina, Brazil, Paraguay, Uruguay	Yes
Organisation for Economic Co-operation and Development (OECD)	38 countries including United States, United Kingdom, Germany, Japan, France, Canada, Australia, etc.	Yes

Table 5: Status of antibiotic use, funding and number of projects for AMR

G20 Countries	Antibiotic consumption in DDDs (The Global Health Observatory, n.d.)	Funding for AMR research (USD millions)	Number of Projects
United States	20	1,107.40	50
United Kingdom	21.5	120.6	15
Sweden	20.9	33.2	15
Denmark	20.8	25.6	14
Germany	22.9	507.4	200
Japan	19.7	234.6	90
Australia	19.9	120.6	50
France	23	347.4	140
South Korea	23.4	174.6	60
Netherlands	20.9	55.6	25
Spain	20.9	94.6	35
Austria	21.2	19.8	9
Ireland	20.9	18.6	9
Greece	21.1	22.4	10
Italy	22.8	243.4	90
China	10.5	107	47

Belgium	21.2	15.2	10
Latvia	20.8	4.8	3
Croatia	21.1	10.4	5
Canada	23.3	61.4	27
Portugal	21	12.6	6
Saudi Arabia	28.1	36	15
Slovenia	20.9	11.2	6
Finland	20.8	22.4	10
Estonia	20.8	6.6	4
Mexico	22.7	24.6	11
Russia	14.9	43.6	18
Indonesia	19.2	10.8	6
India	23.5	30.6	14
Slovakia	20.9	12	6
Lithuania	20.8	7.2	4
Czech Republic	21.1	24.6	11
Poland	21	20.4	9
Cyprus	21.1	3.6	2
South Africa	21.4	40.6	16
Türkiye	24	33.6	
Malta	21	2.4	1
Bulgaria	20.5	7.2	4
Hungary	21	10.8	5
Luxembourg	21	12.6	6
Romania	20.8	13.2	6

Table 6: G20 countries and this status on AMR/AMC surveillance through GLASS

Country	AMR (Anti-microbial resistance)	AMC (Anti-microbial consumption)
Australia	Y	
Canada	Y	
China		
France	Y	
Germany	Y	Y
India	Y	
Indonesia	Y	Y
Italy	Y	Y
Japan	Y	
Mexico		
Republic of Korea	Y	
Russian Federation	Y	Y
Kingdom of Saudi Arabia	Y	
Republic of South Africa	Y	
the Republic of Türkiye	Y	
United Kingdom	Y	Y
United States of America	Y	

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Notes

[1] "The Review on Antimicrobial Resistance (AMR), was commissioned in 2014 by David Cameron, the then UK Prime Minister. The Review was helmed by economist Jim O'Neill and analysed the global problem of rising drug resistance. It also proposed concrete actions to tackle AMR internationally. The Review on AMR was jointly supported by the UK Government and Wellcome Trust, although operated with full independence from both. Established as a two-year, time-limited process, the Review engaged widely with international stakeholders, and produced its final report and recommendations in the summer of 2016.

[2] An antimicrobial drug sensitivity breakpoint system assesses the susceptibility of micro-organisms at particular concentration of antibiotics and is used to classify bacteria into 3 interpretive categories – susceptible, intermediate or resistant.