Five years of National Action Plans on Antimicrobial Resistance:

What impact on surveillance?

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ABSTRACT

Antimicrobial resistance is described in alarming tones globally. By 2020, dozens of National Action Plans have emanated from the Global Action Plan on AMR, with one of the objectives focusing on improving surveillance and reporting. However, bar self-assessment surveys, little is known about their degree of implementation and effectiveness in producing data. I aimed to provide an answer to the last question by using quantitative proxies extracted from the GLASS database that I contrasted to a qualitative analysis of sixty national action plans from the six WHO regions. I then tried to explain the challenges that face the implementation of these documents via semi-structured interviews with experts in the field of AMR.

The results show good overall alignment with GAP objectives of surveillance, reporting and international collaboration that does not translate to data. Most countries are not sharing quality data on WHO's Global Antimicrobial Surveillance System, in a trend that crosses income and geographical lines. In most cases, poor reporting is the direct result of substandard data collection, but it is also explained by poor impetus to volunteer labor-intensive data, hence the need for WHO to make a use-case to countries to incentivize data sharing. Our results also indicate a battery of challenges that face NAP implementation related to political will, policy environment, financing, buy-in, socio-cultural dynamics, regulation, and One Health application, among other issues. Reducing AMR starts with understanding these problems and considering the various drivers that move it; factors that are indivisible from other drivers of health and country development.

AKNOWLEDGMENTS

Truth be told, when I embarked on this master's I had not a clue what I wanted to explore and study for a thesis. A couple of months in, a friend remarked how I tended to light up, sit straighter and engage longer whenever antimicrobial resistance was the focus of a lecture or a presentation. The latter was indeed a topic that had pre-occupied me much during my years both as a medical intern and practitioner. Resolving my mind and sending the Lord a prayer, I fired up the Google. A project idea was born, then a protocol and a sweeping pandemic that put a halt to the wheel then axed it altogether. An amendment to said project saw the same fate, only for a third plan to take off. This is the result of that third attempt.

A first thank you to my supervisors, Ernst Kristian Rødland and Christoph Gradmann, for taking every chance to encourage and assist me during the past thirty months, and for presenting me with opportunities that both utilize and advance my skills.

Another thank you to all the participants who were so generous with their time and expertise, and were kind enough to not only provide answers, but links, reports, and contacts.

I also extend my thanks to all the friends who had my back, either with a kind word, a study sesh, a tip, or a bag of fruits. In the words of a not-so-wise DJ: I appreciate you.

Finally, I give my greatest gratitude to my family and my dad in particular without which I would not be here. You made it possible, you deserve any and all of the glory and none of the blame. That, I reserve for Covid.

ABBREVIATIONS

AGISAR	The WHO Advisory Group on Integrated Surveillance of Antimicrobial Resistance
AMR	Antimicrobial Resistance
AMU	Antimicrobial Use
ANSORP	The Asian Network for Surveillance of Resistant Pathogens
AST	Antimicrobial Susceptibility
DDD	Defined daily dose
E. Coli	Escherichia coli
EARS-Net	The European Antimicrobial Resistance Surveillance Network
ECDC	The European Centre for Disease Prevention and Control
EMA	European Medical Agency
ESAC-Net	The European Surveillance of Antimicrobial Consumption Network
FAO	The Food and Agriculture Organization
GAP-AMR	The Global Action Plan on AMR
GBD	The Global Burden of Disease
GDP	The gross domestic product
GLASS	The Global Antimicrobial Surveillance System
HICs	High-income countries
HIV	Human immunodeficiency virus
IACG	The Interagency Coordination Group on AMR
IT	Information Technology
JPIAMR	The Joint Programming Initiative on Antimicrobial Resistance
LICs	Low-income countries

LMICs	Low- and middle-income countries
MRSA	Methicillin resistant Staphylococcus Aureus
NAP	National Action Plan
NIPH	The Norwegian National Institute of Public Health
NORM	The Norwegian Surveillance System for Antimicrobial Drug Resistance
OIE	World Organization for Animal Health
PCR	Polymerase chain reaction
SDGs	Sustainable Development Goals
TB	Tuberculosis
TrACSS	Tripartite AMR Country Self-assessment Survey
UMICs	Upper-middle-income countries
WHO	World Health Organization
WHO AFRO	The WHO Africa Regional Office
WHO EMRO	The WHO Eastern Mediterranean Regional Office
WHO EURO	The WHO Europe Regional Office
WHO PAHO	The WHO Americas Regional Office
WHO SEARO	The WHO South-East Asia Regional Office
WHO WPRO	The WHO Western Pacific Regional Office

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INTRODUCTION

"Never has the threat of antimicrobial resistance been more immediate and the need for solutions more urgent", said Dr Tedros Adhanom Ghebreyesus, Director-General of The World Health Organization (WHO), in January 2020 press release [1]. This statement encapsulates the essence of the multiple warnings issued by many reports in recent years. Under the most alarming scenario, antimicrobial resistance (AMR) will be responsible for an estimated 10 million deaths per year globally by 2050 if no action is taken [2].

The 2015 Global Action Plan on Antimicrobial Resistance (GAP) has generated political momentum worldwide, leading to the development of 130 National Action Plans (NAPs) by December 2020 [3]. Among other objectives, countries joining the GAP commit to AMR surveillance and reporting and are supported by the WHO Global Antimicrobial Resistance Surveillance System (GLASS) which provides guidelines and aims to facilitate data collection, analysis, and standardization [4]. As of December 2020, 99 countries have joined GLASS [5]. Nevertheless, the Interagency Coordination Group on AMR (IACG) has described some NAPs as "Boilerplates", warning that the use of standard templates has not translated to progress on implementation [6]. And while more and more countries are joining the ranks of GLASS, there is little to no knowledge on the quality of submitted data.

Using a mixed methodology, this study aims to investigate the impact of national action plans on AMR surveillance data. It is all the more relevant as surveillance of AMR is an incremental step in combatting its spread, as no strategy can be crafted without accurate data. This study tries to answer one main question: Are national action plans on AMR effective in producing and reporting quality surveillance data? This is done by exploring three objectives:

- The describe countries engagement in AMR surveillance and reporting,
- To analyze and contrast AMR rates with NAPs commitment,
- To understand the challenges facing NAPs implementation and data production.

LITERATURE REVIEW

A. The global state of AMR

1. AMR in numbers

Antimicrobial resistance occurs when infection-causing microorganisms become resistant to medication that is meant to fight them [7]. It results in reduced efficacy of antibacterial, antiviral, antiparasitic and antifungal drugs, making it difficult and expensive to treat infections [8]. While it is a natural process powered by Darwinian selection, the emergence of resistance is accelerated by the use of antimicrobials in humans, animals and agriculture [2]. Indeed, antibiotic consumption in human medicine increased by 65% between 2000 and 2015, from 21.1 to 34.8 billion defined daily doses (DDDs) [9]. According to the Food and Agriculture Organization (FAO), over 60,000 tons of antimicrobials are used globally per year in the livestock sector, a number that is expected to rise by 67% in 2030 to over 105,000 tones [10]. As to agriculture, it estimates a global consumption varying from 63,000 to 240,000 tones/year [10]. Undeniably, animal, and agricultural antimicrobial use far exceeds human consumption.

AMR poses a global public health challenge. While its magnitude and impacts are still broadly unknown; all attempted estimates report worrisome results. Mortality data by the Global Burden of Disease (GBD) 2019 study indicate more than 138,000 deaths due to multidrug-resistant and extensively drug-resistant tuberculosis and HIV infections in 2019 [11]. The widely cited 2014 review on AMR, chaired by Jim O'Neil, estimates 700,000 annual deaths due to AMR, a number that could increase to an extraordinary 10 million by 2050 if no action is taken [2]. Although the numbers of the report are rightfully criticized for being speculative and poorly evidenced [12], as well as possibly too large by the writers' own admission [2], the general message they try to demonstrate still holds: AMR poses a dangerous threat, one that will translate economically as well. The World Bank estimates point to two scenarios of AMR impacts: in the optimistic case, the annual global gross domestic product (GDP) will likely fall by 1.1% by 2050. The worst- case scenario, on the other hand, indicates a global GDP fall that would reach 3.8% by the same year [7].

All these numbers remain attempted estimates as the true burden of AMR is very hard to evaluate due to the absence of a standardized approach of assessment and the scarcity of AMR surveillance data globally, and in potential AMR hotspots particularly [13]. Identifying these hotspots; however,

is tricky. Research is looking at metagenomics analyses of urban sewage as a novel and sustainable approach to predict AMR [14], but it is an expensive approach that requires sophisticated laboratory infrastructure and expertise which remains out of reach for many countries [14]. So in the absence of AMR rates, scholars rely on what is considered the second-best option: antibiotic consumption.

2. AMR and Metrics

A 2018 paper by Klein et al. concludes that the 65% increase in human antibiotic consumption between 2000 and 2015 is driven by low- and middle-income countries (LMICs): from 11.4 to 24.5 billion DDDs, a 114% increase, while high-income countries' (HICs) consumption increased by only 6% from 9.7 to 10.3 billion DDD [9]. The writers also mention an unreferenced statement about a "well-quantified relationship between antibiotic use and resistance" which can lead to an easy conclusion: LMICs are hotspots of AMR and require immediate intervention. However, relying on gross consumption numbers leads to a superficial and biased read of the data. The more accurate indicator is consumption rates. By all accounts, LMICs consumption is below that of HICs as shown in a figure from the same paper [Figure 1]. In 2015, HICs like the USA and France consumed an average of 25.7 DDDs per 1000 inhabitants per day, while upper middle income countries like Turkey and Brazil consumed and average of 21.3 DDDs per 1000 inhabitants per day, and low and lower middle income countries like India and China[1] an average of 11.9 DDDs per 1000 inhabitants per day [9]. Using the former logic, HICs are a bigger hotspot of AMR and require more immediate intervention.

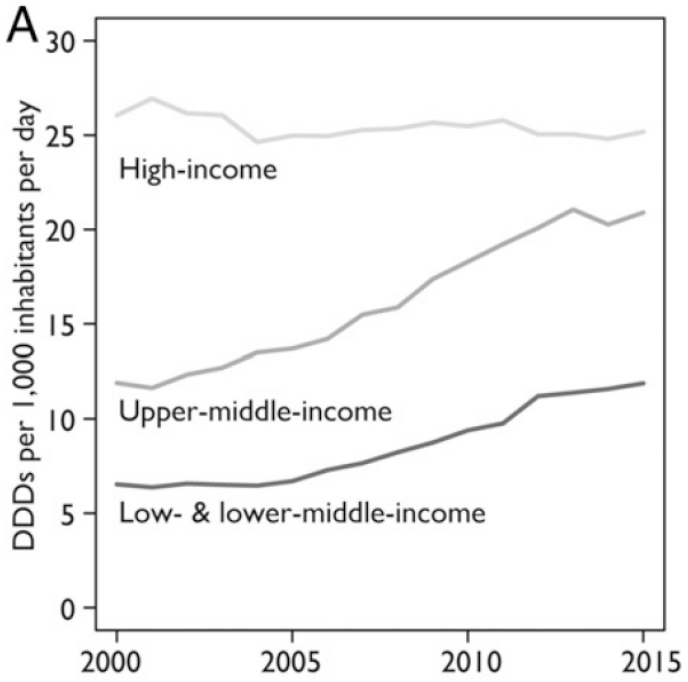

Figure 1: "Global antibiotic consumption by country income classification: 2000–2015. (A) Graph showing how the antibiotic consumption rate in DDDs per 1,000 inhabitants per day has rapidly increased for LMICs, while remaining nearly constant for HICs" [From: *Klein EY, et al.,* Global increase and geographic convergence in antibiotic consumption between 2000 and 2015. *Proceedings of the National Academy of Sciences, 2018.* ***115****(15): p. E3463.]*

[1] In 2015, China was recategorized as an upper-middle income country.

The writers explain the rise in LMICs antibiotic consumption by a positive correlation with gross domestic product per capita (GDPPC) growth. From a global social justice point of view, I argue that these countries cannot be criticized or penalized for making long economic and social strides, improving poverty rates, access to education and antibiotics, sanitation, mortality rates and other indicators of a better life. These parts of the world are merely catching up with wealthy countries, with some nations achieving public health and economic strides even faster than they did [15].

In essence, the assumptions may be correct. It is, indeed, possible that LMICs are the major hotspots of AMR and require the most urgent intervention to curb this potential disaster. However, we are doing ourselves a disservice by relying on biased indicators and falling for what the Swedish epidemiologist Hans Rosling describes as the size instinct, or how we tend to get things out of proportion [15]. The assumptions may be correct, but the language used to broach them is problematic. Associating gross antibiotic consumption with AMR levels and thus responsibility of action provides HICs with an easy way out. It harkens after another instinct described by Dr. Rosling: the gap, or the US vs THEM outlook [15]. Such an indicator divides the world in such a way that lays premature blame at the feet of one party and hinders the chances of imperative international and collaborative initiatives.

In a 2016 article assessing the political feasibility of a global collective action on AMR, Katwyk et al. categorized countries into four types according to their GDP as a proxy for influence, and gross antibiotic consumption change as a proxy for self interest in action [16]. Looking at Figure 2, we notice that many of the influential and wealthy countries are situated in the bottom half where gross antibiotic consumption has not increased. They fall under what the team calls the "initiators," a resourceful group tasked with initiating action on AMR. A logical question would be: What is their incentive? Given how our metrics of choice are all but relieving them of responsibility. The authors recognize that attracting participation is not an easy feat, noting that the feasibility of a global agreement is conditioned by its benefits outweighing its cost and harm for all states involved [16]. If the current pandemic with the novel coronavirus has proven anything; however, it is that expressing public health matters in such blunt economic terms is not enough to generate collaboration. Nurturing trust between states and upholding their respective responsibilities is essential to bring about commitment and international action [17]. When it comes to AMR, that responsibility is

shouldered by looking at the right numbers. Gross antibiotics consumption data are like shadows in Plato's cave wherein they look a lot like reality but are far from being very meaningful.

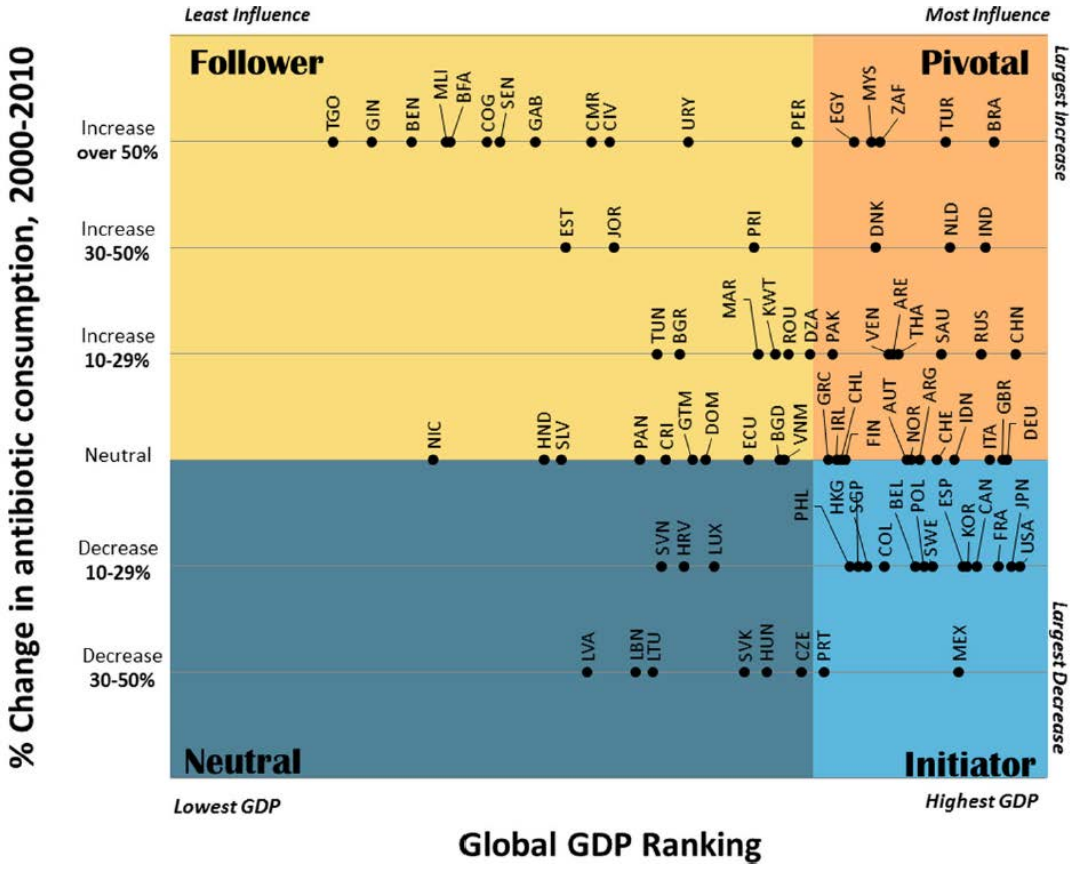

Figure 2: "Global influence (GDP ranking) against self-interest in addressing AMR (10-year percent change in human antibiotic consumption). Four typology categories (Pivotal, Initiator, Follower and Neutral) representing different roles in addressing AMR are overlaid" [16]

Researchers have recently come to similar conclusions, demonstrating that AMR is not merely determined by antimicrobial consumption, but that socioeconomic and governance factors play significant roles. A 2018 analysis of 103 countries by Colignon et al. found that poor infrastructure and governance were significantly associated with higher levels of AMR, contrary to antimicrobial consumption which was poorly corelated with the observed AMR levels [18]. Another 2021 study by Silva et al. on determinants of AMR among different European countries found that low per capita expenditure on health and high private health expenditure were associated with a higher rate of AMR,

concluding: “Considering antibiotic consumption as the most important factor contributing to AMR may be a deviant focus” [19].

The findings of studies like this may have major policy implications. They shift the focus from antimicrobial consumption to a holistic approach that tackles all aspects of health care: improving public expenditure, sanitation, infrastructure, human resources, infection control and prevention, etc. [18, 19]. However, the conclusiveness of their results is hindered by incomplete datasets. Limitations include missing or incomplete data on human antibiotic consumption, resistance rates and antibiotic use in animals, which have led the writers to emphasize the need for robust surveillance systems and a One Health approach [18, 19]. We then find ourselves confronted with a vicious cycle wherein understanding AMR and its determinants is challenged by poor data, which stems from poor surveillance, which is the result of poor local and international funding, which is the result of poor global incentive for influential countries to get involved, which in turn is the result of insufficient understanding of AMR and its consequence (Figure 3). Breaking this cycle requires long-term thinking on the part of influential countries, and an investment in surveillance which will provide us with the data and the knowledge to better fight AMR.

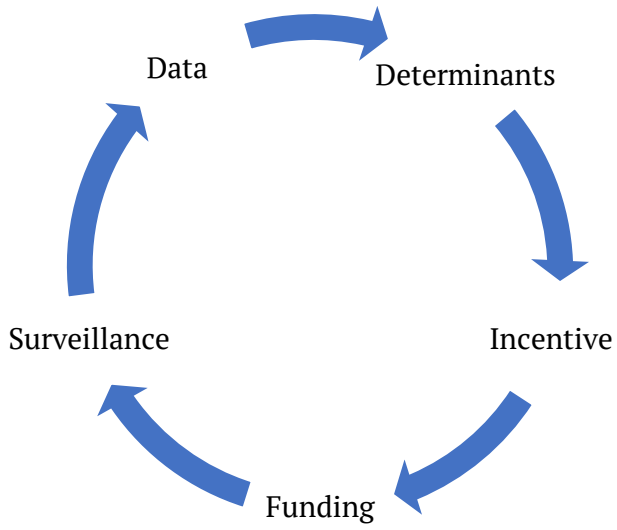

Figure 3: Poor action on AMR is the result of a vicious cycle

B. AMR surveillance: a brief history

Today, "One Health" is a staple concept featuring in many a symposium, university program, research project and publication. The term is a recent addition to the lexicon, coined as late as 2004 following the publication "Manhattan Principles on One World – One Health" [20]. However, the principles of One Health aren't new as our awareness of the interdependent relationship between humans, animals and the environment is as old as humanity itself.

In the field of antimicrobial resistance, and perhaps a testament to that understanding, the first monitoring efforts occurred in animals about three decades after the introduction of antibiotics in veterinary medicine in the late thirties of the past century [21]. Salmonella surveillance was first started in France in 1969 [22], followed by the UK in 1970 [23]. And while the debate on the use of antimicrobials and the risk of resistance had not quietened; with notable WHO-led efforts to standardize testing globally in the 60s [24]; it took an additional two decades for the first monitoring program in humans to see the light [25]. 1996 was a breakthrough year: the United States established the National Antimicrobial Resistance Monitoring System (NARMS) which included human specimens in its compendium [26], the Asian Network for Surveillance of Resistant Pathogens (ANSORP) was created in South Korea and provided valuable information on AMR in the region [27], and that same year, the WHO published the first set of guidelines on AMR surveillance geared towards laboratories and outlining testing methodology, indicator organisms and antimicrobials to be tested [28]. Then followed the European Antimicrobial Resistance Surveillance Network (EARS-Net) in 1998 [29], the Norwegian Surveillance System for Antimicrobial Drug Resistance (NORM) in 2000 [30], and the Canadian Integrated Programme for Antimicrobial Resistance Surveillance (CIPARS) in 2002 [31]. Increased concern about AMR in the new millennium saw more countries following suit and many networks being created. In 2017, Ashely et al. took stock of supranational AMR surveillance networks involving LMICs since 2000 and identified 72 that were involved in surveillance of bacteria, fungi, HIV, TB and malaria, 34 of which were still ongoing [32].

Despite all initiatives, many limitations and challenges have been described across the board. A 2017 paper by Tacconelli et al. described European national surveillance efforts that were "fragmented and heterogeneous and have substantial structural problems and issues with laboratory data", had "different goals and little or no coordination, harmonization, or information sharing with

international networks" [33]. They also cite potential obstacles with regards to poor standardization of epidemiological definitions, data collection, sharing and publication [33], while Ashely et al. reported that the main challenges facing international networks have been achieving high coverage across LMICs and complying with the recommended frequency of reporting [32]. Therefore, there was a palpable need for a global surveillance effort that would unite all states in the fight against AMR and reduces the remarkable differences in action. Enter the Global Antimicrobial Resistance Surveillance System, better known as GLASS. In 2015, the WHO introduced the program to support a global action plan on AMR with the goal of collecting, analyzing and sharing standardized and comparable AMR data with all countries and partners [4, 34]. The WHO coupled its initiative with manuals, guidelines and support tools designed to help countries develop their own national action plans and track data on key pathogens.

As of December 2020, 99 countries have enrolled in GLASS [5], and 130 countries have declared developing a national action plan according to the 2019-2020 Tripartite AMR Country Self-Assessment Survey [3]. The numbers may seem encouraging if not impressive, yet the rule goes "Quantity does not guarantee quality". So the question remains: Are these action plans working and are they producing quality data?

C. NAPs Evaluation: efforts and obstacles

Available literature on our topic of interest; "The evaluation of AMR NAPs"; is scarce and not targeted. The question: "Has AMR national actions plans' impact been quantitively measured?", has understandably, not been answered. This is to be expected considering the relative novelty of the movement and the difficulty of the task in the absence of international consensus.

Indeed, the International Coordination Group on AMR (IACG) concluded in a discussion paper published in 2018 that when it comes to NAPs, implementation is the real challenge [6]. Drafting these documents is often reduced to a copy-paste of standard templates and tools provided by the WHO. This is particularly true for LMICs who fall largely under the third category of the Tripartite AMR survey: "countries with a plan but having difficulty in implementing" [3]. The IACG identified several obstacles facing this category: Lack of coordination or implementation mechanisms, the presence of logistical, technical or institutional challenges, and insufficient funding and resources [6]. However, and according to the same document, the task can be just as daunting for HICs who are

plagued with poor political will, extreme bureaucracy, and weak procedures. Case in point, a recent work by Katwyk et al. published in 2020 and titled "Ten Years of Inaction on Antimicrobial Resistance: An Environmental Scan of Policies in Canada from 2008 to 2018", reveals that Canada, one of the wealthiest countries in the world, has no clear idea on the effectiveness of policies adopted as far as 1997, and concludes that Canadian interventions have been "too few, too small and too uncoordinated" to properly confront AMR [35].

Anderson et al. published their work on a governance framework for development and assessment of NAPs on AMR in 2019 [36]. The framework is a checklist covering three main bodies: policy design, implementation tools, and monitoring and evaluation, each broken down into several areas. The monitoring and evaluation checklist covers reporting, feedback mechanisms, effectiveness, and AMR research, and asks questions that are most relevant to our research topic as shown in Figure 4: on progress reports and data collection and sharing, particularly of AMR rates.

Panel 3: Antimicrobial resistance governance framework: monitoring and evaluation

Domain one: reporting

- Are annual antimicrobial resistance (AMR) national action plans (NAPs) progress reports published?
- Are annual surveillance reports published containing data regarding the incidence of resistant organisms and antimicrobial use?
- Is there collaboration with and systematic data transmissior to international surveillance systems?

Figure 4: AMR governance framework: reporting. [From: Anderson, M., et al., A governance framework for development and assessment of national action plans on antimicrobial resistance. *Lancet Infect Dis, 2019]*

This framework, while useful, raises questions on feasibility and applicability in low-resource settings, namely low- and low-middle income countries. Surely it is not merely a question of what ought to be done, as that's covered by official WHO guidelines such as the GLASS guide to planning, implementation, and monitoring and evaluation [37]. It is primarily a question of means and international cooperation, which makes this work more relevant to wealthier countries. The authors do conclude that there is need for "international leadership to develop consensus and engagement from national policy makers" [36]. This conclusion hearkens back to Katwyk et al.'s own conclusion in their 2016 article on global collective action on AMR: Wealthy countries with expertise and resources are essential to develop collaborative action on AMR [16].

Anderson et al.'s framework was adapted by Chua et al. in an analysis of NAPs on AMR in South East Asia published in 2021 [38]. The team tested the alignment of NAPs objectives with the Global Action Plan on AMR, then assessed and compared five governance areas that include policy design,

implementation tools, monitoring and evaluation, sustainability, and One Health management. While they provided input into policy priorities and identified areas that require strengthening, they contributed no knowledge on implementation and how well these plans were translated on the ground. This type of work can nonetheless be considered a steppingstone and a testament to the interest this topic is generating amongst researchers.

METHODS

I have mined three sources of data to achieve the objectives of this study: NAPs documents, GLASS data, and semi-structured interviews. The distinct nature of these sources required I apply a mixed methodology to study them. Qualitative and quantitative methods are complementary, and when aggregated allow for a more comprehensive and targeted approach of the phenomenon [39]. In this case, the phenomenon was the impact of NAPs on AMR data and the challenges facing their implementation.

I have therefore employed two methods to investigate. The first is a comparative analysis contrasting the country's engagement in AMR surveillance, reporting and international collaboration with actual AMR data reporting. The second is semi-structured interviews to understand the challenges facing NAPs implementation.

A. Document analysis

I used the 2019-2020 Tripartite AMR Country Self-assessment Survey (TrACSS) as the starting point of the selection process [3]. One hundred and twenty countries had declared successfully developing a National Action Plan, out of which 82 had joined GLASS by mid-2019 according to the WHO's 2020 GLASS early implementation report [40]. I had public access to 69 of these documents via the WHO's library of AMR NAPs [41] and the European Centre for Disease Prevention and Control's (ECDC) online publication page [42]. To allow for a fairer comparison of NAPs and GLASS data, I excluded 7 documents that were developed during or after 2019. I also excluded 2 documents of which I could not obtain satisfactory translations,

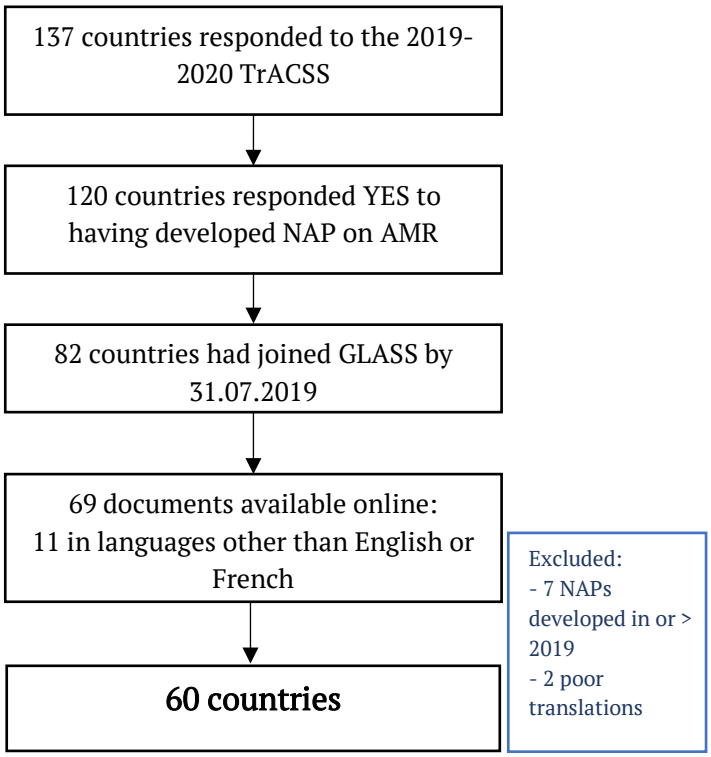

Figure 5: Flow chart explaining the document selection process

while 9 were translated to English using the Professional version of DeepL, the neural machine translation service [43]. In total: 60 documents were included in this study.

I used the World Bank categories to divide countries into four income groups: low-income countries (LICs), lower-middle-income countries (LMICs), upper-middle-income countries (UMICs) and high-income countries (HICs) [18]. Country sampling covered all six WHO regions: the African Region (AFRO), the South-East Asia Region (SEARO), the Western Pacific Region (WPRO), the Region of the Americas (PAHO), the Eastern Mediterranean Region (EMRO), and the European Region (EURO) [19].

I analyzed the 60 documents using an iterative process of skimming, reading, and interpretation. The first run-through served to extract the purpose of the NAP and the stakeholders involved as well as familiarize myself with the structure of the documents. I then developed an initial list of codes that I grouped into three categories: 1) Surveillance, 2) Reporting, and 3) International Collaboration. I proceeded to familiarize myself with the process by studying six documents, and here I credit Chua et Al.'s study "An analysis of national action plans on antimicrobial resistance in Southeast Asia using a governance framework approach" with helping me define the types of information to extract and the format in which I summarized them (APPENDIX B) [38]. The list of codes went through several rounds of checking, addition and omission as new codes and patterns emerged, allowing for a combined approach of deductive and inductive coding. The latter was done on NVivo 12 before coding summaries were extracted and refined on Excel, and a final round of coding was done to account for any mistakes or oversight.

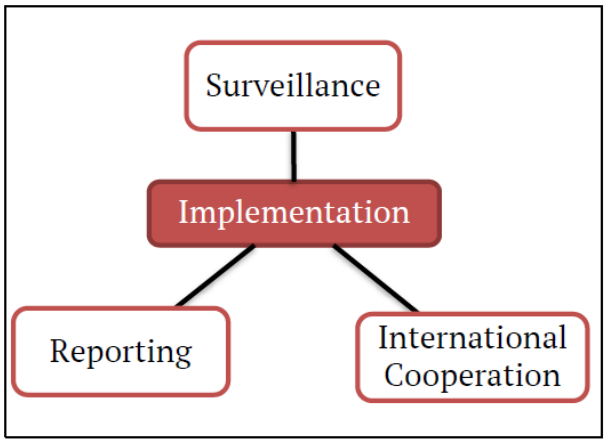

Figure 6: Conceptual framework for assessing NAP implementation: Three areas of interest

B. Quantitative analysis of GLASS data

In order to evaluate AMR data reporting, I chose two measures to serve as proxies: The proportion of *Escherichia coli* (*E. Coli)* resistance in urine isolates, and the proportion of methicillin resistant *Staphylococcus Aureus* (*MRSA*) in blood isolates. The first choice was motivated by a few reasons:

a) Urinary tract infections are some of the most common infections globally [44],

b) *E. Coli* is the dominant culprit across all types [44],

c) *E. Coli* resistance is commonly tested and reported,

d) is in line with WHO's new Tricycle protocol for global One Health surveillance of AMR which is based on Extended Spectrum Beta-Lactamase producing *E. Coli* (ESBL) [45].

The proportion of *MRSA* in blood isolates was chosen for the following reasons:

a) *MRSA* is the cause of significant morbidity and mortality worldwide [46],

b) is routinely tested for [46],

c) is in line with the new 2020 Sustainable Development Goals (SDG) AMR indicator monitoring the "Percentage of bloodstream infections due to selected antimicrobial-resistant organisms"; one of which is *MRSA* [47].

Data were obtained from the WHO's GLASS data repository on the platform Tableau Public [48]. Each country profile contains summaries of AMR data displayed in a color-coded system: The first page shows the proportion of data submission (Figure 7), and the second an overview of reported data with AST results presented in bar charts (Figure 8).

At the time this study was designed, the latest data available were from the 2020 GLASS data call [49]. I extracted the resistance rates of *E. Coli* to six antibacterial families: 4th and 3rd generation cephalosporins (C4G and C3G), Fluoroquinolones, Sulfonamides, Carbapenems, and polymyxins. These included 12 antibiotics: Cefepime, Ceftazidime, Cefotaxime, Ceftriaxone, Ciprofloxacin, Levofloxacin, Cotrimoxazole, Ertapenem, Imipenem, Meropenem, Doripenem, and Colistin. I then calculated the *E. Coli* resistance rate that will serve as the first proxy by averaging resistance rates to the different antibiotics.

A similar process was followed to determine the *MRSA* resistance rate. I extracted the resistance rates of *Staphylococcus Aureus* to Cefoxitin and Oxacillin, both antibiotics from the β -lactam family. Once averaged, I obtained the second proxy.

In addition to resistance rates, I also extracted information with regards to the percentage of unknown AST results of each antibiotic, the number of infections as well as their origins. All data were compiled and analyzed on StataSE 16.

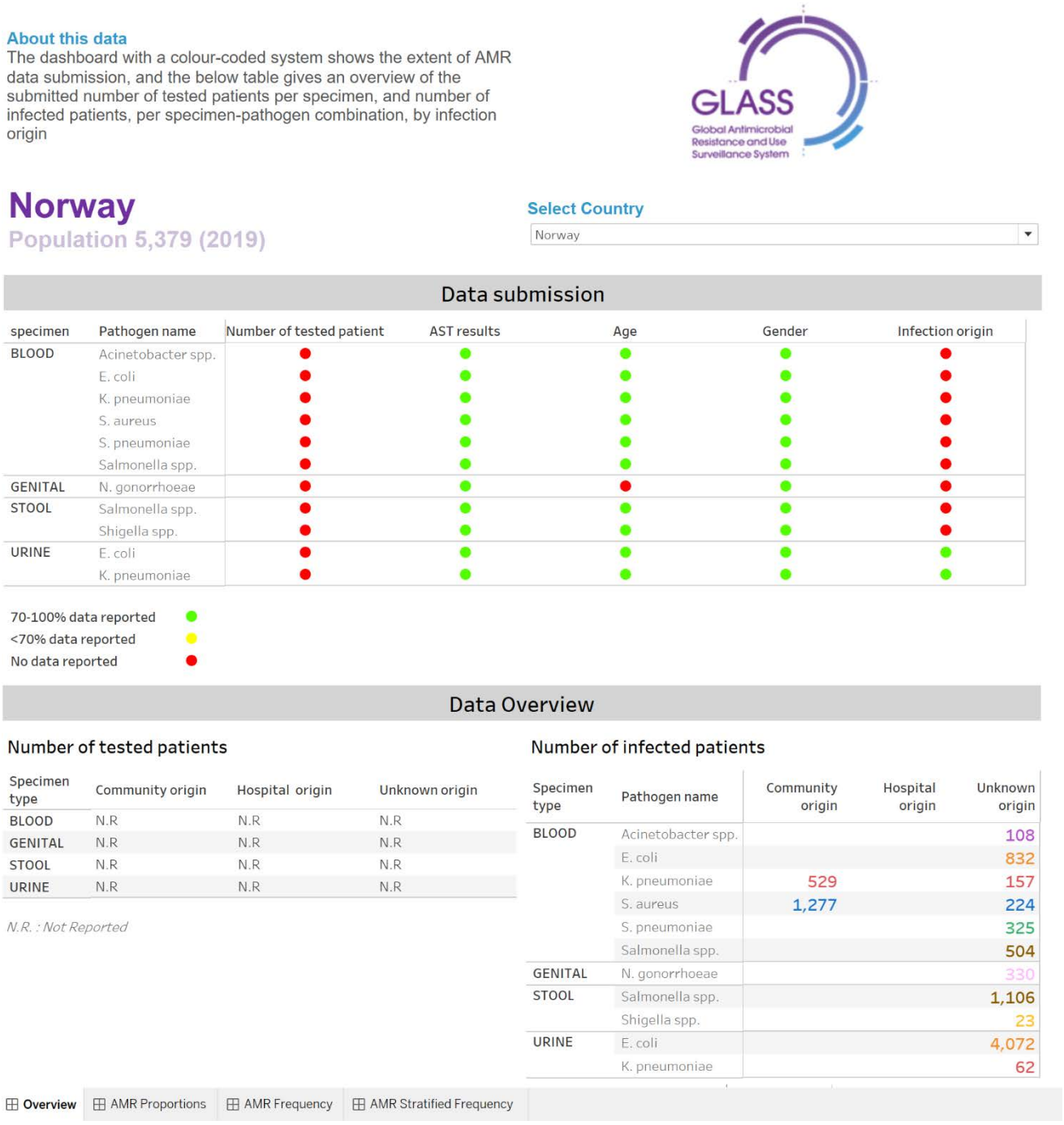

Figure 7: GLASS profile on Tableau public, Overview page. Example from Norway

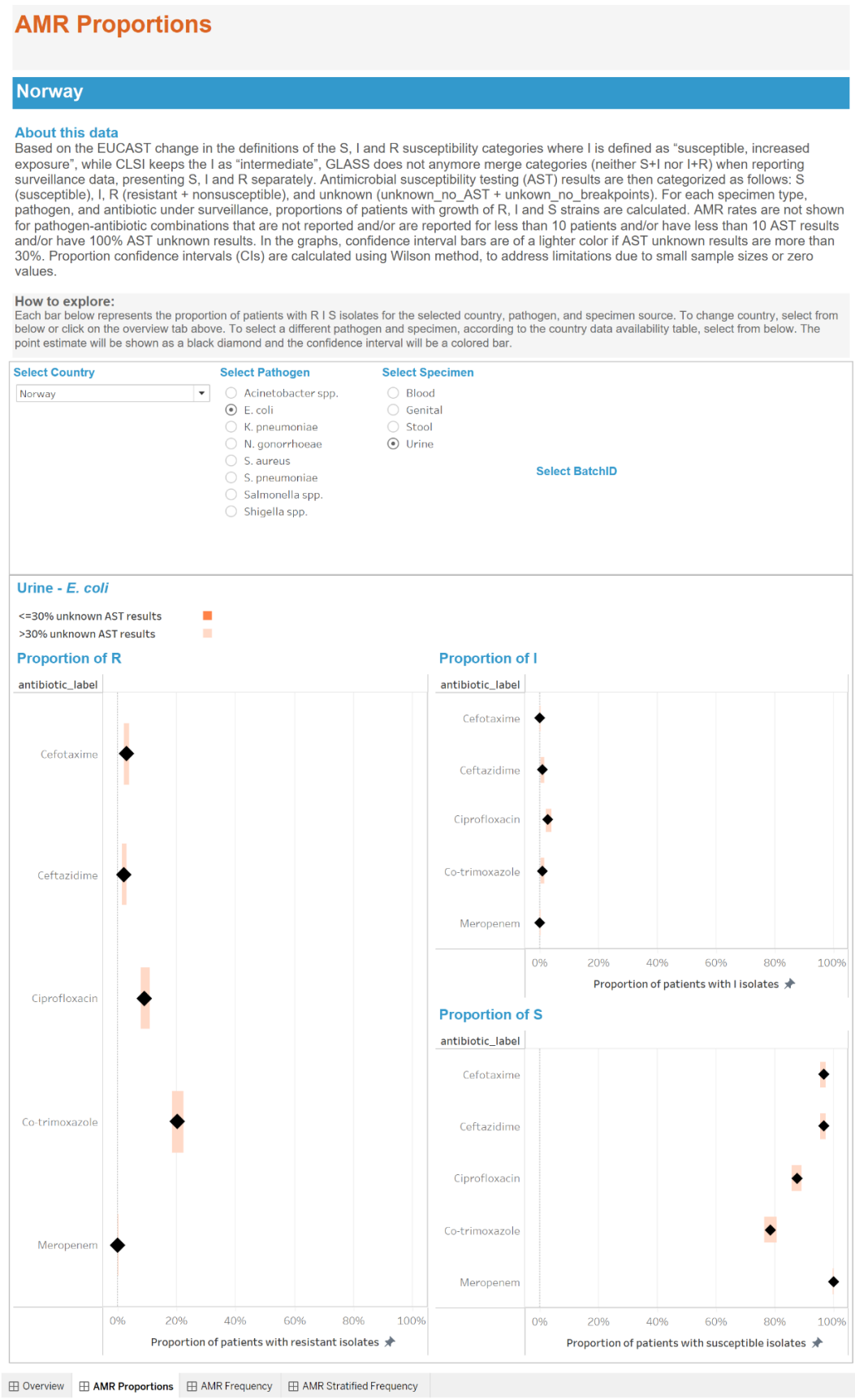

Figure 8: GLASS profile on Tableau public, AMR Proportion page. Example from Norway

C. Semi-structured interviews

The third source of data was semi-structured interviews with AMR experts. This format allows a great degree of flexibility and openness that made it possible to pursue new themes and incorporate new questions, both during a single interview and the course of the process. The interview guide (APPENDIX A) has three parts: Introductory questions, follow-up and probing questions, and a summary. While this format was closely followed in all interviews, the questions were restructured and the focus shifted as the interviewee revealed new ideas that warranted exploration.

After a brief introduction of my research, the interviewee was asked about what kindled their interest in AMR and their expertise. Probing questions were then molded around the answer as well as previous knowledge of the interviewee's publications and research. They concerned three topics: NAP implementation challenges, international collaboration on AMR reduction, and AMR metrics and drivers. When all three have been covered, I asked the interviewee for any additional thoughts which at times prompted further reflections and suggestions of relevant contacts to interview. The interview was then concluded.

Using purposeful sampling, I had reached out via cold emails to a total of 36 key persons with expert knowledge in the field of AMR and National Action Plans. Six accepted the invitation, 20 have not responded, and 10 declined, 6 of which provided references to other contacts. The six interviewees are from the Norwegian National Institute of Public Health (NIPH), the WHO's regional office in Africa, The London School of Hygiene & Tropical Medicine (LSHTM), and the international network ReAct. The interviews were conducted online using Zoom which offered many advantages with regards to ease of scheduling, recording, and time-effectiveness, as well as acceptance from participants [50]. The time length of the interviews varied from 43 to 65 minutes, with an average of 51 minutes. Audio recordings were obtained with the permission of the interviewees and stored on Oslo University's services for sensitive data (TSD), and changes were made during transcription to ensure the anonymity of the participants: Names were replaced by the first initial, and any identity revealing information was omitted.

Transcriptions were imported to NVivo where I coded the content inductively while browsing. I mention here that the sources of data: Documents, GLASS and interviews were exploited and analyzed in this order.

D. Theoretical approach

I chose a grounded theory approach to answer the research question. According to Charmaz, grounded theory is appropriate when there is little known about the topic as data form its foundation of and the analysis of said data generates the concepts that we construct [51]. Thus, it was beneficial in producing a model that explains what challenges face the implementation of NAPs on AMR. It also allowed for new and unexpected themes to arise from the data and made possible to see themes' differences and commonalities. My research started with data that I constructed through document collection and interviews, I then proceeded to code and analyze as I continued to gather data. It allowed me to immerse myself in the data and follow a systematic and clear coding procedure both for documents and transcripts, as well as minimize the risk of including personal biases.

I am; however, aware of the many forms and schools the theory has shaped into and the challenges posed by the perceived necessity to subscribe to one or the other. Timonen et al. sought to demystify the theory in a 2018 article by identifying four principles that constitute its core: 1) To ensure that theory is grounded in data at all times, 2) to capture and explain context-related processes and phenomena, 3) to constantly engage with data, and 4) to pursue theory generation whenever possible [52]. So I aim instead to build on these core ideas and what makes grounded theory the more pragmatic choice for this study, namely: upholding an inductive and flexible approach to the collection and interpretation of data, constant comparison and memoing to support coding and advance categorization, as well as keeping in mind the requirements and challenges of theoretical sampling [52].

RESULTS

A. Document analysis

In May 2015, the World Health Assembly adopted the Global Action Plan on AMR (GAP-AMR) and has urged all Member States to develop their own National Action Plans, underscoring the need for a One Health Approach. According to the 2021 Tripartite AMR country self- assessment survey, one hundred and thirty countries have declared developing a NAP as of December 2020 [3].

I have limited our analysis to 60 countries that span the six WHO regions: 11 African [53-63], 4 American [64-67], 10 Eastern Mediterranean [68-77], 20 European [78-96], 10 South-East Asian [97-105], and 5 Western Pacific [106-110] (Figure 9). Of these, 26 are HICs, 12 UMICs, and 22 LLMICs.

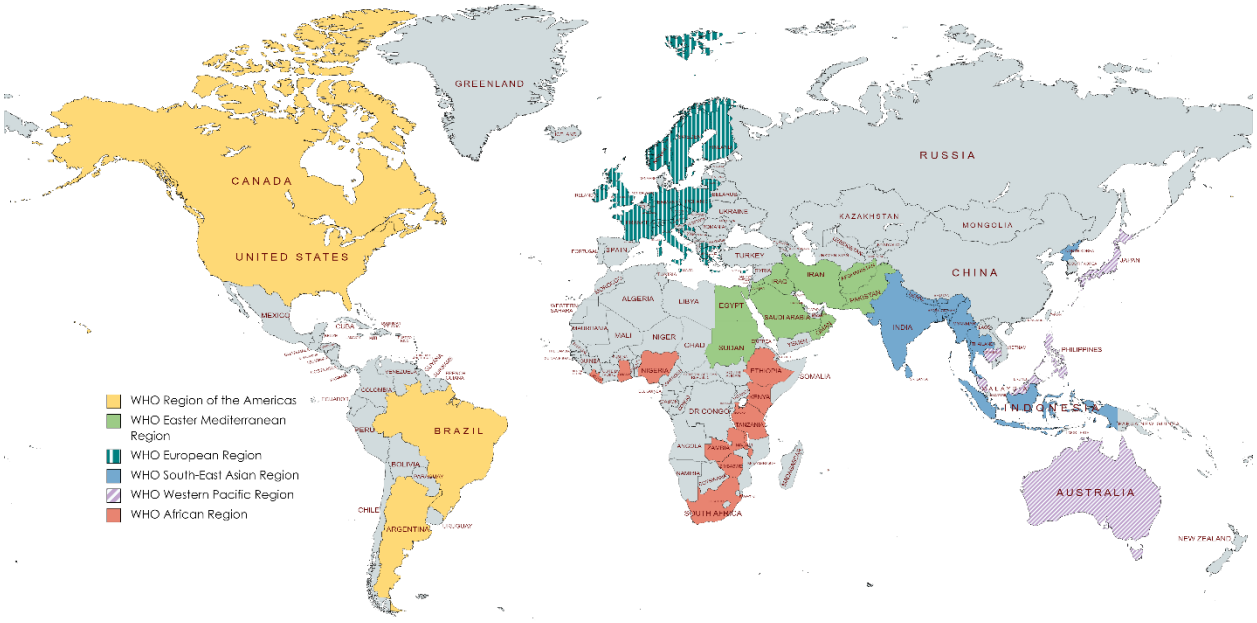

Figure 9: Regional distribution of the sixty countries included in this study. [Created with mapchart.net]

Only five documents were developed before 2015, the rest were developed during that year or later. For some like Ethiopia and the UK, this was the continuation and an update of pre-existing policy and NAPs (1, 2), while this was the first official document for most.

> ***(1) Ethiopia:*** *"To understand the national situation, Ethiopia did a situation assessment, launched its first strategy in 2011, and took action to contain AMR, as detailed in the blue boxes found throughout this strategy. This updated version of the strategy was in response to the revised health and medicines policies, health sector transformation plan, and the resolutions of the 68th World Health*

Assembly of May 2015 and so that Ethiopia's efforts could be coordinated with global initiatives in the prevention and containment of AMR." [53]

(2) UK: *"The UK was one of the first countries to establish a National Action Plan (NAP) on AMR (even before the GAP), with a strategy and action plan in place as early as 2000. In 2013, we reinforced our NAP approach with a One-Health perspective and published our first fully integrated five-year strategy for tackling AMR across human and animal health." [96]*

I observed stark differences between the documents of LMICs and those of HICs, both structurally and contentually. As I will elaborate further, many LMICs NAPs border on being identical copies. A metaphor came to mind while working: If fighting AMR were an onion, most LMICs are barely peeling the tunic while most HICs are digging in the flesh.

Appendix B is a summary containing descriptions and main features of included NAPs.

1. Surveillance

a. Pre-existing surveillance systems in human health

a.1. Antimicrobial Resistance

Of the 60 countries investigated, 28 mentioned existing AMR surveillance systems in hospitals and or community settings predating the conception of the NAP document. Of these, 18 were European countries which are all members of the European Antimicrobial Resistance Surveillance Network (EARS-Net), with the exception of the UK and Switzerland. Notably, 21 were HICs and 7 were Upper MICs. This was the first effort to develop an AMR surveillance system for all low and lower middle-income countries included in this study.

Many countries like Norway and the UK describe National surveillance systems that are robust and well-functioning. The UK reports:

"In the UK, we have human and animal surveillance systems and levels of research coordination and collaboration that are respected by many of our global partners and we want to share our good work and innovative approaches while continuing to learn from the best." [96]

I took note; however, of a few shortcomings that many of these systems suffer from, such as poor data integration wherein AMR data are collected in silos and not communicated effectively:

***Canada**: "In Canada, there are multiple surveillance systems at different levels of government that collect data on AMR and AMU in human and animal settings such as hospitals, community settings and farms. These systems are not all connected and this hinders good integration of AMR and AMU data." [66]*

In other instances, data collection was partial and unrepresentative of the extent of AMR in hospitals or the community. I highlight the example of Iran whose surveillance system only included patients hospitalized for more than 24h, and that of India whose Network only collected data from 15 centers.

***Iran**: "Surveillance system for health care-associated infections in the country was established in 2007 by the Center for Communicable Disease Control, Health Deputy, to regularly collect data on the four main types of health care-associated infections in the country (urinary tract infections, surgical site infection, pneumonia, and blood infection) and analyze and publish periodic reports and provide feedbacks to the authorities at all levels in all public and private hospitals. The target group of the program includes all patients who are hospitalized for more than 24 hours in a hospital; the program does not include peoples receiving outpatient services and those who develop infections after discharge from hospitals." [71]*

***India**: "The Indian Network for Surveillance of Antimicrobial Resistance (INSAR) reported MRSA prevalence rate of 41% based on data from 15 tertiary care centres," [100]*

Poor information technology infrastructure in some countries holds significant consequences on data reporting and quality. In Lithuania's example, AMR data were being collected and reported manually:

"The Order makes the previously voluntary submission of data mandatory for all Lithuanian microbiology laboratories. However, data from microbiology laboratories on the resistance of monitored micro-organisms are collected and entered manually, and not all microbiology laboratories are yet reporting data." [88]

Poorly structured and disorganized policies can impact even the most extensive monitoring systems as is the case in France:

"France has an extensive monitoring system that covers resistance to antibiotics as well as antibiotic consumption in human and veterinary medicine. However, the large number of actors in

human medicine and the redundant nature of some of their assigned tasks impair the effectiveness and efficiency of the monitoring system, especially for resistance to antibiotics." [82]

The absence of real time notification is another challenge as seen in Cyprus:

"Data concerning the antimicrobial resistance of microbes isolated from all clinical samples of hospital and outpatients in the microbiological laboratories of all state hospitals are sent to the Microbiology Department of the Nicosia General Hospital, and are converted using WHONET software into a common database. The data will be stored and processed for inference at the Health Monitoring Unit of the Ministry of Health. New data will be entered and analysed on an annual basis." [80]

Lastly, some countries report having established AMR surveillance systems without further details as to implementation or reporting resistance data in the situation analysis. I bring forth the example of The Democratic People's Republic of Korea which states:

"For continuous monitoring and evaluation of the emergence of AMR in nationwide, National surveillance system on AMR has already been established and operationalized with National AMR reference laboratory in Pyongyang Medical College under Kim Il Sung University and provincial and county level laboratories." [99]

The text suggests that an AMR surveillance system is already in place, but no data are provided to support its implementation.

a.2. Antimicrobial Use

Of the 60 countries included in this study, 23 mentioned existing AMU (Antimicrobial use) monitoring systems in human health. Of these, 17 are European countries which are all members of the European Surveillance of Antimicrobial Consumption Network (ESAC-Net), again except for the UK and Switzerland. I also note that 20 of them were HICs and 2 UMICs, and none were low or lower MICs.

These systems suffer from a few reported weaknesses as well; disintegration being at the forefront. In the previous section we mentioned Canada as a prime example of a country who, despite significant advancements, struggles still with siloed data collection and disconnected systems:

"In Canada, there are multiple surveillance systems at different levels of government that collect data on AMR and AMU in human and animal settings such as hospitals, community settings and farms. These systems are not all connected and this hinders good integration of AMR and AMU data." [66]

Another main weakness is the collection of data that is partial or poorly informative of the sources of AMU. I cite four examples: Iran, whose AMU data were exclusively sourced from insurance data as the system did not have access to non-insurance prescription data, and who struggles, additionally, with non-prescription drug sales at pharmacies [71] (1). The second example comes from Greece whose system did not allow geographical breakdown of data, and wherein consumption in private hospitals and clinics was not incorporated with hospital consumption but pharmacy sales (2). The third example is Japan whose data collection concerns inpatients alone (3). And the last one is Finland whose statistics do not make the distinction between use in acute and long-term settings (4).

***(1) Iran**: "The committee collects data on insurance copies of physicians' prescriptions and registers the data on a national central server; then, it processes the data and identifies drug prescription patterns in the country and supervises the application of the right principles of prescribing by physicians. In addition, the committee runs education and research need assessments to promote the culture of drug use among the members of medical community and the public." [71]*

***(2) Greece:** "In Greece there is a database within the National Agency for Medicines, which was created in 1993 based on the rules and definitions of the WHO. The database contains electronic and monthly data on the sale of pharmaceutical substances by pharmaceutical companies and pharmacies, including antibiotics. The data are divided into sales to private pharmacies and hospital pharmacies. No breakdown by geographical area is possible. Consumption data has the advantage of including OTC sales, but does not distinguish the exact destination of sales with prescription data. In addition, the consumption of private hospitals and clinics is included in community sales, since they do not have pharmacies and their drugs are distributed through private pharmacies." [84]*

***(3) Japan**: "However AMU surveillance has been implemented among inpatients as a national research project, the state of AMU is mostly unknown among outpatients, which counts 90% of the prescription, and among residents in nursing care facilities, except the sales of antimicrobials."[108]*

***(4) Finland**: "Currently, there is no reliable understanding of how the Finnish hospital antimicrobial use has been developing in comparison with other European countries since the Fimea statistics do not allow for the separation of the antimicrobial use data in acute hospitals and long-term care facilities." [81]*

Poor information technology affects AMU data collection as well. I, again, cite Lithuania's example which collects both AMR and AMU data manually:

"Data from the State Medicines Control Service under the Ministry of Health of the Republic of Lithuania, the State Patients' Fund under the Ministry of Health of the Republic of Lithuania and PHC facilities on the consumption of antimicrobial medicinal products are collected and processed manually." [88]

b. Laboratories

The Global Action Plan (GAP) outlines five objectives to fight AMR [34]. The document details these objectives by laying out a set of actions to be followed by member states. Within these is an emphasis on strengthening laboratory and diagnostics capacity:

Objective two focuses on the importance of surveillance and research to strengthen knowledge and AMR evidence base, it calls for a national surveillance system that:

"includes at least one reference laboratory capable of susceptibility testing to fulfil the core data requirements, using standardized tests for identification of resistant microorganisms and operating to agreed quality standards;"

and

"has the capacity to detect and report newly emerged resistance that may constitute a public health emergency of international concern, as required under the International Health Regulations (2005)."

Objective four advocates for an optimized use of antimicrobials and stresses the importance of:

"laboratory capacity to identify pathogens and their antimicrobial susceptibility in order to guide optimal use of antimicrobial medicines in clinical practice;"

Finally, objective five calls on increased investment in new diagnostics among other things, stating:

"Member States are encouraged to participate in international collaborative research to support the development of new medicines, diagnostic tools and vaccines"

I can summarize the main points of the GAP's laboratory strategy as follow:

1) Strengthen laboratory capacity,
2) Standardize testing and data reporting,

3) Create a reference laboratory center,
4) Quality assurance,
5) Early resistance detection and warning systems,
6) New diagnostic tools and technologies.

Virtually every document included in this study has delineated the improving of laboratory and diagnostics capacity as a primary objective, albeit in varying terms and with different targets. I mentioned at the start of this chapter the impression of a divide between the documents of HICs and those of LMICs. That feeling is starkest when pouring over this part.

Broadly speaking, we observe that most low and middle-income countries focus on the first five points. All the thirty-four countries included describe the need to strengthen laboratory capacity:

***Zambia**: "[To] build capacity (human, material, and infrastructure) in network laboratories to conduct AMR activities" [62]*

***Nepal**: "[To] strengthen and expand the national laboratory-based surveillance of antimicrobial resistance by gradual inclusion of more participating laboratories. [And] Capacity strengthening of participating laboratories by providing technical support for investigation, refresher trainings and logistic support in case of need." [104]*

***North Macedonia**: "To provide access to the microbiological laboratory services. To prepare guideline for cooperation between laboratories with respect to access provision. [And] to provide performing and provision of adequate diagnostic tests, microbiological identification, tests for AMR susceptibility for key pathogens, as well as timely and relevant information for the results." [90]*

Twenty-six LMICs commit to standardizing testing methods and guidelines:

***Malaysia**: "[To] establish a standard method for AMR analysis covering various antibiotics" [109]*

***Jordan**: "Unifying national laboratories standards and guidelines in accordance with international standards (CLSI, etc…)" [73]*

***Kenya**: "[To] standardize Methods of Laboratory Testing and Strengthen Testing Functions of Antimicrobial Resistance at Public and Private Laboratories" [55]*

Twenty-nine have designated or are in the process of setting up a reference laboratory:

***Tanzania**: "[To] assess the existing laboratories' capacity and appoint one laboratory to be a national reference laboratory and appoint laboratories to carry out AMR surveillance in human, animal, plant and environmental health" [61]*

***Maldives**: "[To] identify National Reference Laboratory (NRL) for AMR Surveillance in Maldives with expertise in methods for confirming and characterizing specific pathogens, susceptibility performing testing" [109]*

***Cambodia**: "[To] strengthen the laboratory in the National Institutes of Public Health (NIPH) to serve as the national reference center for diagnosis of AMR." [107]*

Twenty-five commit to the continued implementation of quality assurance programs for laboratories:

***Iraq**: "[To] participate in laboratory quality assurance system (internal and external)." [72]*

***Argentina**: "To ensure the quality of surveillance results, participating laboratories have standardized laboratory procedures, internal quality control manuals, external quality control and personnel training programs, and continuous provision of bibliographic updates and reference strains." [64]*

***India**: "[To] establish routine EQAS [External Quality Assurance Services] for all surveillance laboratories." [100]*

But only eleven out of the thirty-four LMICs are investing in an alert mechanism for early detection of emerging resistance:

***Ethiopia**: "[To] extend alerts about new and emerging antibiotic resistance issues to a wide range of professionals. [And] use the generated information to monitor trends, as an early warning system, and to determine risk factors and drivers of resistance" [53]*

***South Africa**: "[To] develop early warning systems of sentinel organisms and outbreaks" [60]*

***Malaysia**: "[To] establish an alert mechanism for AMR detection and reporting of newly emerged resistance that may constitute a public health emergency of international concern." [109]*

Having said that, I could not help but notice a certain genericism that stretched at times to a blatant cut-&-paste. I illustrate this with two examples where we notice a glaring resemblance of both form and content: the first contrasts Afghanistan to India, and the second Timor-Leste to Myanmar:

Afghanistan

Strategic Priority 2

Strengthen knowledge and evidence through surveillance
Laboratory capacity

Objective 2.1

Invent and Strengthen microbiology laboratory capacity for AMR surveillance in human, animal, food and environmental sectors*

Strengthen interventions and activities

2.1.1 Strengthen capacity for laboratory- based surveillance of AMR in humans, animals, food and environment

2.1.1.1 Develop national strategy based on system/lab assessments to strengthen microbiology (including private sector) for antimicrobial susceptibility testing (AST) in medical labs, ensuring SOPs, quality assurance and community data (MoPH) S-M

2.1.1.2 Develop national strategy based on system/lab assessments to strengthen microbiology (including private sector) for antimicrobial susceptibility testing (AST) in animals, food, ensuring SOPs, quality assurance and community data (MAIL) S-M

2.1.1.3 Develop national strategy based on system/lab assessment to strengthen microbiology laboratories (including private sector) for antimicrobial resistance and antimicrobial residues in the environment, including waste from farms, factories and healthcare settings (MoPH, MAIL) S

2.1.1.4 Strengthen capacity for laboratory-based surveillance of AMR with species level identification of bacteria in humans during health and disease; surveillance lab under national network including private sector (MoPH) S

- (<1 year): 5-10 labs; M (1-3 year): 10-20 labs; L (>3 years): >30 labs

2.1.1.5 Strengthen capacity for laboratory based surveillance for AMR in animals, food and environmental M

- Animal sector (MAIL)
- Food sector (MAIL, MoT)
- Environmental sector (NEPA)

2.1.1.6 Establish routine EQAS for all surveillance laboratories M L

- Human labs (MoPH)
- Animal labs (MAIL)
- Food Labs (MAIL, MoPH)
- Environment Labs (MoPH, NEPA)

2.1.1.7 Organize joint training workshops for bacterial identification, antimicrobial susceptibility testing (AST) and data harmonization S-M

- Humans (MoPH)
- Animals (MAIL)
- Food (MAIL, MoPH)
- Environmental (NEPA, MoPH)

Key out puts

- Strategic plan developed to strengthen microbiology laboratories for AMR surveillance in humans, animals, food and environment
- Training workshops held for AST in medical and food labs and environment labs

2.1.2 Designate national reference laboratories for AMR surveillance in humans (also in animal, food and environmental sectors) as pre-requisite for enrolment in GLASS

2.1.2.1 Identify and strengthen national reference laboratories for confirmation and detailed characterization of target pathogens and external quality assessment scheme for AMR organized in human health (MoPH) S

2.1.2.2 Identify and strengthen national reference laboratory(ies)for confirmation and detailed characterization of target pathogens and external quality assessment scheme for AMR in animal and food sector (MAIL, MoPH) S

2.1.2.3 Afghanistan enrollment in GLLAS – Global AMR Surveillance System (MoPH) S-M

Key outputs

- National AMR reference labs designated
- Afghanistan enrolled in GLASS

India

Strategic priority 2

Strengthen knowledge and evidence through surveillance

Laboratory capacity

Objective 2.1

Strengthen microbiology laboratory capacity for AMR surveillance in human, animal, food and environment sectors*

Strategic interventions and activities

2.1.1. Strengthen capacity for laboratory-based surveillance of AMR in humans, animals, food and environment

2.1.1.1. Develop national strategy based on system/lab assessments to strengthen microbiology laboratories (including private sector) for antimicrobial susceptibility testing (AST) in medical labs, ensuring SOPs, quality assurance and community data (**NCDC**, ICMR) **S-M**

2.1.1.2. Develop national strategy based on system/lab assessments to strengthen microbiology laboratories (including private sector) for antimicrobial susceptibility testing (AST) in animals, food, ensuring SOPs and quality assurance (**ICAR**, DADF, FSSAI) **S-M**

2.1.1.3. Develop national strategy based on system/lab assessments to strengthen microbiology laboratories (including private sector) for antimicrobial resistance and antimicrobial residues in the environment, including waste from farms, factories and healthcare settings (**MoEFCC**, CPCB, ICMR, ICAR, NCDC) **S**

2.1.1.4. Strengthen capacity for laboratory-based surveillance of AMR with species level identification of bacteria in humans during health and disease; surveillance labs under national network including private sector (**NCDC**, ICMR)

- **S** (<1 year): 10-15 labs; **M** (1–3 years): 15-30 labs; **L** (>3 years): >30 labs

2.1.1.5. Strengthen capacity for laboratory-based surveillance of AMR in animals, food and environment **M**

- Animal sector (**ICAR**, DADF)
- Food sector (**FSSAI**)
- Environment sector (**MoEFCC**, CPCB)

* Animals include food animals (i.e. terrestrial livestock such as poultry, dairy and aquatic livestock such as fisheries), pets and other large animals. Food is primarily from animal sources and includes honey, milk, eggs, meat, fish and sea food, but does not exclude agricultural produce such as cereals, fruits and vegetables.

2.1.1.6. Establish routine EQAS for all surveillance laboratories **M-L**

- Human labs (**IAMM**)
- Animal labs (**ICAR**)
- Food labs (**FSSAI**)
- Environment labs (**MoEFCC**)

2.1.1.7. Organize joint training workshops for bacterial identification, antimicrobial susceptibility testing (AST) and data harmonization **S-M**

- Humans (**NCDC**, ICMR, WHO)
- Animals (**ICAR**, DADF, FAO, OIE)
- Food (**FSSAI**, FAO)
- Environment (**MoEFCC**, UNEP)

Key outputs

- Strategic plan developed to strengthen microbiology laboratories for AMR surveillance in humans, animals, food and environment
- Training workshops held for AST in medical labs, animal and food labs and environmental labs

2.1.2. Designate national reference laboratories for AMR surveillance in humans (also in animals, food and environment sectors) as a pre-requisite for enrolment in GLASS

2.1.2.1. Identify and strengthen national reference laboratories for confirmation and detailed characterization of target pathogens and external quality assessment scheme for AMR organized in human health (**NCDC**, ICMR) **S**

2.1.2.2. Identify and strengthen national reference laboratory(ies) for confirmation and detailed characterization of target pathogens and external quality assessment scheme for AMR in animal and food sector (**ICAR**, DADF, FSSAI) **S**

2.1.2.3. India's enrolment in GLASS – Global AMR Surveillance System (**NCDC**) **S-M**

Key outputs

- National AMR reference labs designated
- India enrolled in GLASS

Timor-Leste

Objective 2.2: Build laboratory capacity under the leadership of a National Referral Laboratory (NRL) to produce high-quality microbiological data for patient and food-safety management and support surveillance activities.

Strategic intervention 2.2 Establish a quality assured national laboratory surveillance network (for AMR surveillance and action)

KEY ACTIVITIES

Under the overall technical guidance of TWG (Surveillance):

2017	1. The National Health Laboratory will be identified as NRL for AMR Surveillance in Timor-Leste. NHL will cater to human, animal and food sector as NRL. The NRLs will develop expertise in methods for confirming and characterising specific pathogens, performing susceptibility testing, organising quality assurance and participating in external quality assurance schemes (EQAS). NRL will subscribe to Thailand EQAS network. The NRLs will coordinate a national network of surveillance laboratories to monitor AMR in human clinical, animal and food samples. Further, environmental surveillance for AMR will be carried out as per 2.1 in human/animal health surveillance labs. 2. Laboratories linked with AMR surveillance sites in 2.1 will be identified by the NRLs. These surveillance laboratories will be capable of identifying target pathogens and perform susceptibility testing as per standard operating procedures (SoP) laid down by the NRLs. Alternatively, the NRLs will establish a specimen storage and transportation system for more efficient use of existing in country laboratory resources. 3. The NRLs, in partnership with Veterinary Lab (MoAF) will develop and share AMR surveillance standards and guidelines, including SoPs, incorporating other intergovernmental standards (OIE/WHO GLASS and AGISAR/Codex) with surveillance labs.
2018	4. NRL will train surveillance staff, clinical staff, and laboratory personnel in AMR surveillance, lab techniques and data management according to international standards (WHO GLASS and AGISAR, OIE, CODEX). 5. Lab surveillance network in support of National AMR surveillance network will be rolled out in limited number of sites (Maliana and Baucau Municipality will be targeted in the pilot phase).
2019-20	6. TWG will conduct a formal assessment of National laboratory surveillance network followed by recommendations for a nationwide scale up. 7. NRL will expand the network into a nationwide quality assured laboratory AMR surveillance network. NRL will establish linkages with international and global surveillance and internationally relevant initiatives (like GLASS, GFN). Reporting to GLASS will commence from surveillance sites recruited and operationalised in initial phase.

Responsible Agency

MoH, MoAF

Partners and Stakeholders

WHO and FAO, Surveillance Department (MoH), National Health Laboratory, National Hospital, Diagnostic Veterinary Laboratory Department

Illustrative Indicators

- National laboratory surveillance network with National Reference Laboratory (NRL) and quality assured network of surveillance laboratories; and
- Laboratory surveillance of AMR strengthened

Myanmar

Objective 2.2: Build laboratory capacity under the leadership of a National Referral Laboratory (NRL) to produce high-quality microbiological data for patient and food-safety management and support surveillance activities.

Strategic intervention 2.2 Establish a quality assured national laboratory surveillance network (for AMR surveillance and action)

KEY ACTIVITIES

Under the overall technical guidance of TWG (Surveillance):

2017	1. The National Health Laboratory will be identified as National Reference Laboratory (NRL) for AMR Surveillance in Myanmar. NHL will cater to human clinical and water samples. Veterinary Diagnostic Laboratories will cater to samples animal, animal feed and food samples and link AMR surveillance with NRL. The NHL will develop expertise in methods for confirming and characterising specific pathogens, performing susceptibility testing, organising quality assurance and participating in external quality assurance schemes (EQAS). NHL will subscribe to Thailand EQAS network for a regular EQAS participation in addition to existing project based NCGM Collaboration. The NHL will coordinate a national network of surveillance laboratories to monitor AMR in human clinical, animal and food samples. Further, environmental surveillance for AMR will be carried out as per 2.1 (8)in human/animal health surveillance labs. 2. Laboratories linked with AMR surveillance sites in 2.1 will be identified by the NHL. These surveillance laboratories will be capable of identifying target pathogens and perform susceptibility testing as per standard operating procedures (SOP) laid down by the NHL. 3. The NHL, in partnership with Veterinary Diagnostic Laboratories will develop and share AMR surveillance standards and guidelines, including SOPs, incorporating other intergovernmental standards (OIE/WHO GLASS and AGISAR/Codex) with surveillance labs.
2018	4. NHL will train surveillance staff, clinical staff, and laboratory personnel in AMR surveillance, lab techniques and data management according to international standards (WHO GLASS and AGISAR, OIE, CODEX)
2018-19	5. Lab surveillance network in support of National AMR surveillance network will be rolled out in limited number of sites (Sites identified in 2.1 (8) will be targeted in the pilot phase).
2022	6. TWG (Surveillance) will conduct a formal assessment of National AMR surveillance network followed by recommendations for a nationwide scale up. 7. NHL will expand the network into a nationwide quality assured laboratory AMR surveillance network. NHL will establish linkages with international and global surveillance and internationally relevant initiatives (like GLASS, GFN). Reporting to GLASS will commence from surveillance sites recruited and operationalised in initial phase.

Responsible Agency

MoHS (NHL, PHL, CEU), MoALI (Veterinary Diagnostic Lab, Veterinary Assay Lab and Directorate of Epidemiology of MoALI)

Partners and Stakeholders

WHO, FAO, OIE

Illustrative Indicators

- National Reference Laboratory (NRL) that has expertise in methods for confirming and characterizing specific pathogens, organising quality assurance and participates in an external quality assurance scheme (EQAS)
- Number of quality assured laboratories supporting AMR surveillance sites
- AMR surveillance standards and guidelines incorporating GLASS standards and other intergovernmental standards
- Surveillance staff, clinical staff, and laboratory personnel trained in AMR surveillance and lab techniques according to GLASS standards
- National AMR testing external quality assurance system
- Performance reports of NRL and national laboratory network

Upon examining NAPs of HICs, we notice that a few recognize the need to improve their laboratory networks, standards, and early warning systems:

***USA**: "[To] create a regional public health laboratory network to strengthen national capacity to detect resistant bacterial strains and a specimen repository to facilitate development and evaluation of diagnostic tests and treatments." [67]*

***Australia**: "[To] agree and implement a uniform standard for laboratory testing methods for antibacterial susceptibility." [106]*

***Italy**: "[To] develop an alert system for early reporting of new resistance profiles integrated with that planned for care-related infections surveillance (by 2020)." [85]*

However, we observe in most of them an implicit acknowledgment of pre-existing functioning laboratory networks which correlates with the number of countries with pre-existing AMR surveillance systems. I read statements like:

***Austria**: "Anchoring of centers with complete microbiological service spectrum (bacteriology, virology, parasitology, mycology) and operation 7 d / min. h12 / 24 h hotline in the Structural Health Plan (ÖSG)" [78]*

***UK**: "[To] further develop standard, evidence-based laboratory testing practice and reporting guidelines, mandating their use where appropriate." [96]*

***Germany**: "The laboratories participating in ARS have almost completely changed their evaluation of resistance testing over to the EUCAST guidelines, which thus allows comparison on an international level, e.g. within the EARS-Net." [83]*

***Switzerland**: "[To] develop and expand the network of reference laboratories for investigating antibiotic resistance and ensure quality assurance in all laboratories. A network will be established on the basis of the existing designated reference laboratories. The core tasks of the network will include the coordination and standardization of laboratory investigations into antibiotic resistance and the associated research and development. Any existing gaps will be closed." [95]*

When addressing the topic of enhancing laboratory capacity, the focus of most HICs (16/26) is on developing and implementing new diagnostics tools and technologies such as rapid tests, genome sequencing, metagenomic analysis, and other molecular-based surveillance methods:

***USA**: "Goal 2 activities include creation of a regional public health laboratory network that provides a standardized platform for resistance testing and advanced capacity for genetic characterization of bacteria (e.g., through whole genome sequencing).*

. Develop and validate new diagnostics—including tests that rapidly distinguish between viral and bacterial pathogens and tests that detect antibiotic-resistance—that can be implemented easily in a wide range of settings." [67]

***Japan**: "Develop new technologies for surveillance and monitoring based on molecular epidemiology and promote their application in public and animal health laboratories.*

. Strengthen surveillance and monitoring based on molecular epidemiology by expanding the AMR genome database and apply the outcomes to risk assessment and risk management" [108]

***Luxembourg**: "In human health, in order to promote and strengthen the use of rapid diagnostic tests, recommendations on the use of certain rapid diagnostic tests will be developed in conjunction with national treatment recommendations. In addition, the use of rapid diagnostic tests will be defined as one of the basic national indicators of an ASP [Antibiotic Stewardship Programme] in all sectors. In parallel, actions will have to be developed to train and inform professionals (prescribers and laboratories) in the use of these rapid diagnostic tests." [87]*

***UK**: "[To] explore options for including new monitoring tools, such as whole genome sequencing and other molecular-based methods, to improve and add value to our surveillance data." [96]*

There are, nevertheless, notable exceptions to this finding. Bahrain, Oman, Saudi Arabia and Croatia are four countries classified as high income but addressing AMR surveillance for the first time. Their NAP documents follow the structure observed in those of LMICs and share a focus on the same objectives as shown through in the following excerpts:

Saudi Arabia:

Objective 4. Build laboratory capacity to produce high-quality microbiological data for patient management and support surveillance activities in both human and animal sectors		
4.1. Designate a national reference laboratory for AMR surveillance	4.1.1. The National lab will assume responsibility for AMR lab in the future. Currently, the AMR Sentinel sites labs will perform required AMR testing and reporting	June 2017
4.2. training workshops for microbiologist and laboratory technicians	4.2.1. Plan for series training, workshops will be formulated for Microbiology doctors and lab technicians for all hospitals> 150 beds	June 2017

Bahrain:

Objective 6	Build laboratory capacity to produce high-quality microbiological data for patient management and support surveillance activities in both human and animal sectors.	
	Strategic interventions	**Activities**
	6.1. Designate a national reference laboratory for AMR surveillance. ***Milestone:*** March 2018	6.1.1. Write and approve terms of reference for a national reference laboratory with expertise in methods for confirming and characterizing specific pathogens and organizing quality assurance schemes. 6.1.2. Establish a reference lab for AMR in animals
	6.2. to prepare the list of the microorganisms that needs to be reported with all the resistant pattern	6.2.1. To prepare the list
	6.3. to establish a program to link all the hospitals for reporting or utilize the WHO-NET program	6.3.1. Communicate with WHO for training 6.3.2. To work on establishing our program
	6.4 to participate in GLASS program by WHO	6.4.1. To get training and starting the program in collaboration with WHO

Oman:

2.1 MDRO Surveillance: Both in Human and Animal

-Standardization of Antimicrobial Laboratory testing and unifying the MDROs definitions.

-Upgrade the Laboratory capacity in all hospitals with qualified human resources and needed to tools to accurately identify MDROs and to identify newly or emerging mechanisms of resistance.

-Ensure the quality of laboratory methods used for identification and antimicrobial susceptibility testing by ensuring the adherence to standard operating procedures (SOP), internal and external quality control schemes

-Establish and upgrade the molecular bacteriology section at the Central Public Health Laboratories to cater as a national reference laboratory for MDROs.

-Adapt a national MDROs surveillance using the Global Antimicrobial Surveillance framework.

-Establish national antibiogram to help in developing treatment guidelines

Croatia:

Goal 1: Reduce the consumption of antimicrobial drugs and the antibiotic resistance of bacteria (in line with the WHO Global Action Plan, Goal 2)

Year of implementation	**Activities**
2017.-2021.	1. Maintenance of the microbiology laboratory network 2. Compilation and analysis of antibiotic resistance data 3. Provision of external quality control 4. Retesting of an isolate of a rare phenotype 5. Washing of isolate of special character 6. Participation in national guidelines on antibiotic use 7. Cooperation with the Ministry of Health's Referral Centre for the Control of Infections in Patients 8. Compilation and analysis of antibiotic consumption data 9. Expression of the right to freedom of expression 10. Participation in the EARS-Net programme (ECDC) 11. Participation in the ESAC-Net programme (ECDC)

Despite technological advances and efforts to strengthen surveillance, some HICs report a set of challenges related to knowledge gaps (a), poor regulation (b), weak standardization (c), the scarcity of high-level expertise institutions (d, e), and the slow uptake of new diagnostic technologies (f):

***Canada**: "While pan-Canadian surveillance systems are producing useful, reliable data on AMR and AMU, there are still significant knowledge gaps in measuring the extent of AMR and AMU in humans and animals. These gaps include limited information for certain settings (e.g. community), the need for benchmarking to assess trends in AMR and AMU and an increased need for the standardization of laboratory and data collection methods, case definitions and improved timeliness of reporting." [66]*

***Austria**: "It is not regulated which qualification is required (knowledge and skills) to be allowed to perform microbiological diagnostics, resistance testing and reporting. Therefore, the results of microbiological diagnostics, resistance testing and reporting differ considerably in all aspects and lead to the interpretation difficulties mentioned under objective 2. The lack or time-limited availability of qualified contact persons exacerbates the problem, which in turn leads to the uncritical and inappropriate use of antibiotics" [78]*

***Australia**: "At present, there is variation between the data sets held in surveillance systems, which may make data comparison at a national level difficult. Different susceptibility testing standards are used in Australian medical and veterinary diagnostic laboratories. These standards are not always concordant on what is considered 'susceptible', 'intermediate' or 'resistant', meaning that resistance in a bacterium identified in one laboratory may be reported differently in another laboratory." [106]*

***Greece**: "It is also noted that, although many (mainly university) laboratories have developed high-level expertise in molecular microbiology, the typing of clinical microbial strains in order to understand how microorganisms are spread in Greek hospitals is not an integrated function in infection control efforts and there are no institutionalised Reference Centres (Standardisation Centres) for this purpose." [84]*

***Japan**: "The number of laboratories capable of conducting detailed analysis on AMR including ARG [antimicrobial resistance gene tests] is still limited, and examination standards, targets, and methods used among them are not standardized." [108]*

***UK**: "In the UK, we do not make the best use of available diagnostic tests. For example, our regulatory requirements for diagnostics make it difficult to assess the value of any new diagnostic test to the overall AMR agenda: if a new promising diagnostic came out tomorrow, the NHS is not equipped to get it into front-line use quickly. Uncertainty about requirements for research evidence, lack of*

engagement to understand frontline needs, and 'silo budgeting' all serve to delay the uptake of new diagnostic technologies." [96]

To summarize: All countries included in this study aim to improve their laboratory and testing capacity per the Global Action Plan's recommendations. I observe a difference in objectives between LMICs and HICs wherein the former focus on building basic infrastructure, and the latter on developing and incorporating new technologies.

c. Surveillance in humans: AMR, AMU, and HAI

c.1 AMR surveillance

All sixty countries commit to monitor antimicrobial resistance. Countries with pre-existing surveillance systems aim to strengthen and improve them through several actions:

- Adopting a One Health integrated approach to better understand the drivers of resistance and how antimicrobials are used:

***Canada**: "AMR and AMU data generated from surveillance systems can be enhanced with the further implementation of an integrated One Health approach to surveillance in Canada, as recommended by the WHO and the OIE, outlined in guidelines from the WHO Advisory Group on Integrated Surveillance of Antimicrobial Resistance and adopted by other G7 countries." [66]*

***UK**: "A systematic approach. This includes understanding the chain of causality and the relationship between health and social care, environmental contamination and clinical disease, including a focus on hospitals as amplifiers of transmission." [96]*

- Increasing the number of participating hospitals and expanding the surveillance network to include regional hospitals as well as primary care:

***Greece**: ". Expansion of the Hellenic Network for the Study of Antimicrobial Resistance (WHONET) to include the country's regional hospitals, with the participation of at least one hospital (preferably the largest) per prefecture. [And to] extend it to primary care (diagnostic centres) for specific surveillance of epidemiologically and clinically important pathogens, such as ESBL in the community and CA-MRSA." [84]*

***Malaysia**: "[To] increase number of participating hospitals in reporting of Antibiotic Sensitivity Test (AST) through WHONET." [109]*

- Updating practices and standards and developing new indicators to measure resistance:

***Austria**: "[To] strengthen and further develop surveillance systems to record and assess antimicrobial resistance and antimicrobial consumption according to best practice models." [78]*

***France**: "At the national and European level, develop new global and specific indicators aimed at measuring antibiotic resistance and exposure to antibiotics on a common basis for humans, animals, and the environment." [82]*

- Implementing real time resistance reporting mechanisms:

***Finland**: "[To] develop real-time notification and reporting system for extremely resistant antimicrobial bacteria to support the exchange of information at the local, regional and national levels with the aim of enhancing appropriate control actions." [81]*

- Setting up data sharing platforms and tools between laboratories:

***South Africa**: "The existing AMR national surveillance system is to be strengthened through sharing of data between laboratories to improve understanding of trends and resistance patterns across the country in both animal and human health." [60]*

This was thirty-two countries' first effort to implement an AMR surveillance system. The intention is stated using different wordings and formulations:

***Saudi Arabia**: "[To] set up a national surveillance system for antimicrobial resistance." [77]*

***Ghana**: "There shall be established national monitoring systems for antimicrobial use and surveillance of antimicrobial resistance to inform policy" [54]*

***Pakistan**: "Establishment of an integrated national AMR surveillance system (human, animal usage and resistance monitoring)." [75]*

***Czech Republic:** "To monitor and analyze antibiotic resistance at the local, regional and national levels with the aim of obtaining systematic data needed for effective antibiotic resistance prevention and control, including the assessment of the effect of the measures taken" [79]*

c.3 HAI surveillance

Virtually all sixty documents endorse the Global Action Plan's third objective of reducing the incidence of infection through effective sanitation, hygiene, and infection prevention measures. However, we found that the second action related to surveillance of Healthcare Associated Infections (HAI) (Figure 10) was explicitly endorsed by just 47 countries.

The objectives of HAI surveillance vary according to pre-existing infrastructure. Altogether, countries with a pre-existing HAI surveillance system aim to improve upon it, and those without aim to establish one. I observe that the first group includes mostly HICs (1) and a few UMICs (2), whilst the second consists mainly of LLMICs (3).

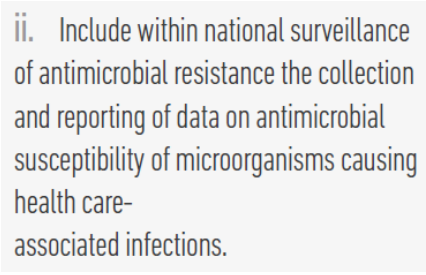
ii. Include within national surveillance of antimicrobial resistance the collection and reporting of data on antimicrobial susceptibility of microorganisms causing health care-associated infections.

Figure 10: From Objective 3 of the GAP

***(1) UK**: "[to] use patient e-records and data links to optimise surveillance of community and healthcare-associated infections (including surgical site infection)." [96]*

***(2) Malaysia**: "[to] strengthen Healthcare Associated Infection (HCAI) surveillance: To revise the HCAI manual [And] To improve reporting system and data collection." [109]*

***(3) Myanmar**: "[To] implement a healthcare facility-based HAI surveillance system along with related AMR surveillance (human health)" [103]*

c.2 AMU surveillance

All sixty countries commit to monitor antimicrobial consumption. Countries with pre-existing surveillance systems aim toward continued and improved surveillance via expanding available networks, information technology, development of better indicators, and establishing reduction targets:

***Canada**: "[To] implement a robust system for collecting AMU data to support continuous improvement of stewardship across the human and animal health sectors." [66]*

***Germany**: "Expanding overall antibiotic consumption surveillance to collate representative data and to provide reference data for the specialist public" [83]*

***Finland**: "[To] develop statistics and IT systems on antimicrobial use to allow for an itemised analysis of antimicrobial consumption data of hospitals and long-term care facilities." [81]*

***Norway**: "In connection with the national quality indicator system, a national quality indicator group has been set up to devise various quality indicators for antibiotic use and health service-related infections. If all goes according to plan, four quality indicators, which can provide a picture of the use of antibiotics at the municipal level, will be published by the end of 2015." [94]*

***Netherlands**: "During the next five years, the objective is to achieve a reduction of at least 50% in the use of incorrectly prescribed antibiotics across the entire healthcare chain, relative to a baseline determined with stakeholders." [91]*

This was thirty-seven countries' first effort to implement an AMU surveillance system. Countries have set up several objectives:

- Monitoring of both antimicrobial prescription and over-the-counter medication (OTC):

***Liberia**: "[To] establish an antimicrobial prescription monitoring system.*

[To] develop AMR prescription reporting system in the context of One Health (animal, human health).

[To] establish a monitoring system for non-prescribed antimicrobials." [56]

***Nigeria**: "monitoring and supervision of drug dispensers to encourage compliance with restriction on OTC sale of antimicrobials" [59]*

- Establishing targets for antimicrobial consumption:

***Zambia**: "To Optimize the use of antimicrobial agents [through] established National target for AM use per capita in human health[and] established National targets for AM prescribing, with systems or incentives to encourage appropriate behaviours." [62]*

- Establishing antimicrobial stewardship programs:

***Jordan**: "Establishing a National Antimicrobial Stewardship Clinical Care Standard, which aims to ensure that a patient receives optimal treatment with antibiotics, including the selection of the right antibiotic to treat their condition, the right dose, by the right route, at the right time and for the right duration." [73]*

- Integrated antimicrobials sale & utilization audit:

***Pakistan**: "[To] coordinate and synchronize record keeping mechanism for antimicrobial sale and use at all levels (pharmacies, medical & veterinary hospitals/ GPs in both sectors).*

. Compilation of national sale and usage record" [75]

- And extending surveillance to the private sector:

***Cambodia**: "[To] monitor the rational use of antibiotics in the public and private sector." [107]*

d. One health integration

One Health is the backbone of the 2015 Global Action Plan on AMR. It is defined as the collaborative effort to obtain optimal health for people, domestic animals, wildlife, plants, and the environment [25]. In our study, most of the documents included are modeled after the GAP and are therefore founded on the same One Health approach. This is stated either explicitly:

***Zambia**: "The country has adopted the "One Health" approach as proposed in the Global Action plan (GAP) on antimicrobial resistance." [62]*

***Luxembourg**: "Within the framework of the National Antibiotic Plan 2018-2022, we have set ourselves the objective of reducing the emergence, development and transmission of antibiotic resistance in Luxembourg according to a "One Health" approach, including human, veterinary and environmental aspects." [87]*

***Philippines**: "This summit is the first step in crafting the "Philippine Action Plan to Combat AMR: One Health Approach," which highlights the urgency to strengthen the surveillance system for AMR, and delve deeper into the advancement of its detection and treatment processes." [110]*

… Or implicitly:

***Iran**: "[To] implement integrated health care system for three sectors including human, animals, environment and foods." [71]*

***North Macedonia**: "Intersectorial character of AMR problem impose the need for integration and coordination of national efforts for AMR control in context of European approach "Health in all policies" especially having in mind the veterinary medicine, education, environmental protection, social protection and finance." [90]*

The three documents that fail to mention One Health have a common denominator: they are early efforts to control AMR that predate the GAP. The Cypriot NAP was developed in 2012, the Czech in 2011, and the Greek in 2008.

Integrated surveillance is another preponderant notion in these documents. Defined by the WHO Advisory Group on Integrated Surveillance of Antimicrobial Resistance (AGISAR), it is the collection, analyses and reporting of relevant microbiological and epidemiological data on AMR from humans, animals, foods and the environment, as well as data on AMU [111]. Countries included in our study commit to integrated surveillance through various formulations:

***Canada**: "[To] establish coordinated platforms and mechanisms to link AMR and AMU data, in particular from human health, animal health and agriculture sectors." [66]*

***Zambia**: "[To] integrate AMR surveillance into the national surveillance system (clinical and laboratory) for human, animal, plant, food, and environment." [62]*

***Malta**: "[To] establish and implement a nationally representative and coordinated programme for surveillance of antimicrobial usage in hospitals, the community, environment, animal and aquatic medicine and agriculture, in both food and non-food, and aquatic production, including by sector and by antibiotic (broad and narrow)." [89]*

***Iraq**: "Establishment of an integrated national AMR surveillance system to monitor and provide a national database regarding antimicrobial resistance." [72]*

In our attempt to unveil any potential discrepancies between intention and action we created different codes for human, animal, environmental and agricultural action on AMR and AMU. These are our findings:

Of the 60 included countries, 57 cite a previous or future commitment to monitoring AMR in animals:

***Ethiopia**: "[To] establish/strengthen national, regional, and health facilities' surveillance systems to detect and report AMR and disseminate information to facilitate decision making on diagnoses and treatments in public health, veterinary practice, and food laboratories." [53]*

***Czech Republic**: "In the veterinary area, certified AC veterinary laboratories have been established with the purpose to diagnose causative agents of infectious diseases in animals and to monitor their resistance status." [79]*

***Cambodia**: "[To] establish a monitoring system for AMR in food producing animals." [107]*

Regarding antimicrobial use in animals, 53 commit to monitoring it either explicitly or not so explicitly:

***South Africa**: "In animal health, the re-introduction of a national longitudinal antimicrobial surveillance programme and reporting of resistance rates in food-producing and companion animals from public and private laboratories will be developed in partnership with DAFF. This will include a system to monitor antimicrobial use and circulation in the country as well as in different livestock sectors." [60]*

***Brazil**: "[To] implement a program to monitor the use of antimicrobials in animals." [65]*

***Thailand**: "[To] reduce use of antimicrobials in livestock farming and fisheries." [105]*

***Ghana**: "[To] establish a system for the national surveillance of antimicrobial use in non-human health." [54]*

I observe a drop in numbers when it comes to environmental action on AMR that is accompanied by a leveling of the playing field with regards to income, as both High and Low- and Middle-income countries struggle to tackle it. Out of 60 countries, 33 commit to some form of action to control AMR in the environment: 46% of HICs and 61% of LMICs[2]. This action includes:

- Monitoring antimicrobials and resistance in waters and soils:

***Luxembourg**: "Currently, in the environmental sector, the presence and concentration of three antibiotics (macrolide class) are monitored in surface waters, under the supervision of the Water Management Administration, according to the vigilance list." [87]*

***Mauritius**: "The National Environmental Laboratory monitors the river water quality annually in terms of bacteriological analysis for E.coli" [58]*

***Norway**: "Mapping of antibiotic resistant bacteria will be carried out in representative environments and selected organisms in animals, water and soil with varying degrees of exposure to antibiotics." [94]*

- Developing new indicators and research projects:

***Finland**: "Propose a basic research programme to be instituted by the Academy of Finland, with special focus on AMR and other infectious disease research as well as on related environmental issues." [81]*

[2] 12/26 HICs and 21/34 LMICs

***France**: "At the national and European level, develop new global and specific indicators aimed at measuring antibiotic resistance and exposure to antibiotics on a common basis for humans, animals, and the environment." [82]*

***Argentina**: "[To] conduct specific studies on the behavior of antimicrobial agents in different biological matrices (water or feed, pre-mix or concentrated nucleus) and on the impact of their use on the environment of production systems." [64]*

- And improving waste disposal:

***Ethiopia**: "[To] ensure proper disposal of unfit-for-use antimicrobials to protect the environment." [53]*

***Iran**: "[To] protect public health and the environment against the adverse effects of medical wastes." [71]*

However, we cannot neglect to mention that many of the stated actions are more akin to blanket statements than proper resolutions. In instances, mention of the environment was limited to the aforementioned pledges of One Health. This is the case of Saudi Arabia who, despite adopting the GAP and its principles in the introduction, draws no action to tackle AMR in the environment in the rest of the document:

***Saudi Arabia**: "This action plan for the Kingdom Saudi Arabia to combat antimicrobial resistance has been formulated in the line of the WHO five objectives. It addresses the need for effective "one health" approach involving coordination among numerous national sectors and actors, including human and veterinary medicine, agriculture, finance, environment, and well-informed consumers." [77]*

Mention of the environment was cursory in other cases and limited to references of integrated surveillance (1, 2) or to strategic objectives without further detailing concrete action as did Bahrain (Figure 11):

***(1) Tanzania**: "[To] develop a multisector AMR surveillance reporting and information sharing system in human, animals, plants and environment health… [And to] establish antimicrobial agents consumption surveillance in human, animals, plants and environment." [61]*

***(2) Iraq**: "[To] establish antimicrobial surveillance system in human, foods, animals, and environment." [72]*

Strategic priority 2 Aims to strengthen knowledge and evidence through surveillance of AMR, with 2 focus areas – strengthening laboratories in human, animal, food and environment sectors, as well as ensuring surveillance of antimicrobial resistance in human, animal, food and environment sectors.

Strategic priority 3 Attempts to reduce the incidence of infection through effective infection prevention and control in healthcare to reduce the burden of infection, in animal health and food to reduce spread of AMR and antimicrobials through animals and food, and in community and environment to reduce the spread of AMR and antimicrobials in the environment.

Figure 11: Excerpt of Bahrain's strategic objectives

On the other hand, we have countries who admit their lack of readiness to tackle the environmental component of AMR:

***Canada**: "Although all types of antimicrobials (e.g. antifungal, antivirals, antiparasitics) are critical for treating infections, the primary focus of the Framework is on bacterial resistance to antibiotics. This issue is of the utmost concern and warrants urgent action due to the significant threat it presents to human and animal health. The human and animal health aspects of the One Health approach are the initial focus of the Framework. As work advances in these areas, the environmental aspect will be considered." [66]*

***Lithuania**: "A growing body of research shows that resistant bacteria are emerging in the environment. This suggests that the release of residues of the active ingredients of antimicrobial drugs into water and soil is another factor contributing to the spread of resistance. However, there are no systematic systems for monitoring bacterial resistance and residues of antimicrobial active substances in the environment, and no standards for the protection of the environment from contamination by antimicrobial active substances yet." [88]*

I observe comparable results with regards to the agricultural sector. Thirty-one out of the sixty documents included mentioned action on AMR in crops and farming which included:

- Monitoring resistance:

***USA**: "[To] collect quantitative data on antibiotic-resistance and management practices along various points at pre-harvest, harvest, and processing stages, in collaboration with producers and other stakeholders, and disseminate information as appropriate." [67]*

***Brazil**: "[To] develop surveillance and monitoring of AMR in the field of agriculture and cattle ranching." [65]*

***Iran**: "[To] create a database of genome-resistant bacteria in the fields of agriculture and aquaculture." [71]*

- Monitoring antimicrobial use and residue:

***Liberia**: "[To] monitor antibiotic residues in animal feed, pesticide residue in honey, in aquaculture and food." [56]*

***Switzerland**: "the current plan would allow investigations to be expanded to include antibiotic residues and resistance in farmyard manures and soil." [95]*

***Ethiopia**: "[To] support the assessment of non-therapeutic use of antimicrobials in veterinary and agriculture settings." [53]*

- And promotion of education and good practices:

***Ghana**: "There shall be continuous education to promote the responsible use of antimicrobials in animal husbandry, aquaculture and crop production with emphasis on the dangers of antimicrobial misuse." [54]*

***Kenya**: "[To] train on good veterinary, agricultural, aquaculture, hygienic practices in various food value chains including risk based measures." [55]*

***Jordan**: "Conducting field orientation visits for farmers regarding the vaccination, biosecurity, feed additives, water purifications, antibiotic use, etc..." [73]*

I, likewise, many documents only mention agriculture in broad strokes:

***Malta**: "Establish and implement a nationally representative and coordinated programme for surveillance of antimicrobial usage in hospitals, the community, environment, animal and aquatic medicine and agriculture, in both food and non-food, and aquatic production, including by sector and by antibiotic (broad and narrow)." [89]*

***Egypt**: "Optimize the antimicrobial use in agriculture." [70]*

2. Data reporting in human health

I set out to answer four questions about reporting in human health:

a. How many countries commit to reporting AMR data?

b. How many countries commit to reporting AMU data?

c. Is the reporting frequency specified?

d. Are there systems in place to share the data internationally?

These are our findings:

a. AMR reporting:

All selected countries commit to reporting on AMR in some form of language that ranges from the explicit to the implicit:

***Afghanistan**: "Annual report of national AMR surveillance with data from all sectors published." [68]*

***Argentina**: "Analyzes and prepares an annual report with the relevant surveillance data, which is disseminated to the laboratories participating in the Network, to all health care providers in the country and to the Pan American Health Organization/World Health Organization; and is published with free access on the website www.antimicrobianos.com.ar" [64]*

***France**: "[To] use a "One Health" approach to provide annual communication to the public and to professionals on consumption and resistance data by prioritising common indicators." [82]*

***Bangladesh**: "[To] ensure monthly report of AST by all selected laboratories." [97]*

***Bahrain**: "to prepare the list of the microorganisms that needs to be reported with all the resistant patterns… [And] to participate in GLASS program by WHO." [69]*

b. AMU reporting:

I reached the same results regarding AMU reporting:

***USA**: "[To] implement annual reporting of antibiotic use in inpatient and outpatient settings and identify geographic variations and/or variations at the provider and/ or patient level that can help guide interventions." [67]*

***Cyprus**: "continued surveillance of antibiotic consumption and participation in the ESAC-net (which allows to view local data in comparison with other European countries and all European sites);" [80]*

***Ethiopia**: "Collection of antimicrobial use data by specific categories, such as human health, animal health, and the food industry, and the data is used for decision making." [53]*

***Netherlands**: "During the next five years, the objective is to achieve a reduction of at least 50% in the use of incorrectly prescribed antibiotics across the entire healthcare chain, relative to a baseline determined with stakeholders." [91]*

***Nigeria**: "[To] organize meeting to define/identify antimicrobial use and practice indicators and develop appropriate data collection and audit tools." [59]*

c. Frequency of reporting:

Only two thirds of countries indicated a reporting frequency for AMR and/or AMU. Ninety-five percent have settled on annual reporting (1, 2, 3, 4), whilst a few engaged in monthly or quarterly reporting as well (5, 6), and one country simply indicated "routine" reporting (7):

*(1) **India**: "Annual report of national AMR surveillance with data from all sectors published." [100]*

*(2) **Poland**: "Summary of data on the use of antibiotics in medicine submitted as annual reports to the European Antibiotic Consumption Monitoring Network (ESAC - Net) and the Ministry of Health." [92]*

*(3) **Tanzania**: "[To] report annually [...] on the trend of antimicrobial use in health facilities." [61]*

*(4) **UK:** "To support cross-sector analysis, the UK publishes a One-Health surveillance report every two years that includes data on antibiotic resistance and use for animals and humans." [96]*

*(5) **Ghana:** "[To] monitor the use of antibiotics in veterinary and aquaculture. Quarterly monitoring reports to be shared with appropriate offices and with the AMR stakeholder platform." [54]*

*(6) **Nepal:** "Monthly, quarterly and annual dissemination of AMR surveillance findings through media (like website, newsletter or bulletins) and respective professional councils." [104]*

*(7) **Kenya**: "Routine reporting of antibiotic use and resistance data to National Coordinating Center by hospitals." [55]*

d. International data dissemination:

Forty-eight countries have mentioned sharing AMR and/or AMU data with international networks. I can broadly classify them in four categories:

- Countries enrolled and sharing data with GLASS and WHO, the most dominant:

***Finland**: "Finland is also participating in Global Antimicrobial Resistance Surveillance System (GLASS) under the auspices of WHO." [81]*

***North Korea**: "National AMR surveillance regularly assessed and adjusted; and contributing to GLASS." [99]*

***Australia**: "Australia will also provide surveillance data to the WHO to inform its global antimicrobial resistance surveillance and to understand how we are performing compared to other countries." [106]*

- European countries enrolled in EARS-Net and ESAC-Net:

***Austria**: "For more than ten years, Austria has been participating in the European networks for the collection of resistance data (EARS-Net = European Antimicrobial Resistance Surveillance Network) and antibiotic consumption data (ESAC-Net = European Surveillance of Antimicrobial Consumption Network)." [78]*

***Luxembourg**: "[To] transmit antibiotic resistance surveillance data to EARS-Net, FWD-Net, GLASS, authorities, the public and professionals." [87]*

- Other avenues, such as sharing with the EU and the World Organization for Animal Health:

***USA**: "Establishment of a common U.S.- European Union (EU) system for sharing and analyzing bacterial resistance patterns for priority pathogens." [67]*

***South Africa**: "[To] share South African data on AMR and antimicrobial use with WHO Global Surveillance of Antimicrobial Resistance (GLASS) and OIE databases to add to global knowledge on AMR." [60]*

- Unspecified sharing networks, as some countries stopped short of naming any and opted for general statements:

***Sweden**: "appropriate data to be collected from relevant sectors and fed back where relevant at local, regional and national level, as well as at EU and international level." [93]*

***Oman**: "[To] establish mechanisms for regular sharing of antimicrobial resistance data across human and animal health environmental sectors at the national, regional and global levels as per global standards." [74]*

***Ghana**: "There shall be a data management system to yield quality surveillance data that can be shared regionally and globally to drive future actions in managing AMR." [54]*

In summary: at the time of NAP conception, all countries commit to report on AMR and/or AMU data. However, not all engage in sharing of collected information.

3. International collaboration

I had started off coding this section with the intention of learning about research collaboration, partnerships, and countries' participation in surveillance networks. While we will touch on these elements further, we have to admit that our focus shifted as patterns emerged regarding the provision and reception of support to establish NAPs and combat AMR.

Broadly speaking, we can sort included countries into two groups: the givers and the receivers. About half mention receiving some form of technical or financial support to establish situation analysis (1), develop national action plans (2), or establish surveillance programs (3). An assistance that was provided by international organizations such as WHO, World Organization for Animal Health (OIE), and FAO (1, 2), as well as western agencies and programs like the United States Agency for International Development (USAID), the United States Center for Disease Control (US CDC) (3), and the Fleming Fund (4). All bar one are low-and-middle income countries.

> ***(1) Philippines**: "the World Health Organization-Western Pacific Regional Office (WHO-WPRO) granted technical support to the DOH to undertake a Country Situation Analysis on AMR in 2012." [110]*

> ***(2) Liberia**: "Partners and institutions who have also significantly contributed include Centers for Disease Control and Prevention (CDC), Food and Agricultural Organization of the United Nations (FAO), Mother Pattern College of Health Sciences, and United States Agency for International Development (USAID). A special recognition goes to the World Health Organization (WHO) for providing technical and financial support throughout this process." [56]*

> ***(3) Egypt**: "The surveillance programme was done in collaboration with the US CDC, Egypt Country Office, USAID in Egypt and the national partners." [70]*

> ***(4) Malawi**: "the MoH would like to sincerely appreciate the United Kingdom (UK) Department of Health through Fleming fund for their overall financial support." [57]*

On the other hand, we took note of eleven countries that discuss various venues to support global action on AMR. Either by providing countries with direct support (1, 2, 3), working on projects targeting low incomes countries (4), or providing the WHO with financial support (5, 6). All of them are high income countries.

*(1) **USA**: "Support countries to develop and implement national plans to combat antibiotic-resistance and strategies to enhance antimicrobial stewardship" [67]*

*(2) **Switzerland**: "[To] Set up and intensify support for developing countries in combating antibiotic resistance." [95]*

*(3) **UK**: "The UK funds projects overseas to help optimise the use of antimicrobials through, for example, initiatives to develop NAPs and roll out key protocols and tools needed to survey AMR and use (see box "The Fleming Fund")." [96]*

*(4) **France**: "In collaboration with the WHO and the OIE, develop a network for monitoring the emergence and spread of resistance to antibiotics (in humans, animals, and the environment) in low-income countries, by relying on existing networks." [82]*

*(5) **Netherlands**: "Good implementation of the WHO Global Action Plan on antimicrobial resistance in the coming years is of great importance. We support the WHO, FAO2 and OIE3 in these efforts. In concrete terms, this includes a specific financial contribution from the Ministry of Health, Welfare and Sport to the WHO, and strategic secondments to the WHO. We are currently discussing a high-level strategic secondment with the WHO." [91]*

*(6) **Australia**: "Australia is providing funding to the Western Pacific Regional Office of the WHO to support low- and middle-income countries in the region to increase their capacity to combat antimicrobial resistance." [106]*

Going back to the initial purpose of this section: 27 countries mention participating or promoting research on AMR: 17 HICs and 10 LMICs. Research that is done either locally (1) or in collaboration with regional (2) or international partners (3).

*(1) **Canada**: "[To] support a cross-sectoral, multidisciplinary research network to facilitate antimicrobial discovery, best practices, behavioural research and economic and production impacts across sectors and jurisdictions." [66]*

*(2) **Philippines**: "the Philippines is actively collaborating with the Ministry of Health Malaysia in the conduct of a rapid assessment for regulatory measures to combat AMR." [110]*

*(3) **Iran**: "[To] promote international collaboration for conducting research on antimicrobial resistance and promote research and development for introducing new methods of prevention, diagnosis, and treatment of antimicrobial resistant infections." [71]*

A few countries remain vague as to said partnerships, speaking of "international collaboration" and "partners" without specification as is the case of Iran, Afghanistan, and Luxembourg (3, 4, 5). Most; however, go on to elaborate and name collaborating bodies and joined initiatives (6-10). I observe that these collaborations naturally follow along regional lines: European countries collaborate through the European CDC, ESAC and EARS networks (8), and Asian countries collaborate through the regional bureaus of WHO, ANSORP, and initiatives like the Jaipur declaration on AMR (9, 10). International cooperation on the other hand is ensured through flagship organizations (WHO, FAO, OIE) and global initiatives like The Joint Programming Initiative on Antimicrobial Resistance (JPIAMR) which now boasts 29 participating countries [112].

***(4) Afghanistan**: "[To] establish an annual forum on AMR for donors and partners to share information and facilitate coordinated mobilization of recourses prioritized AMR activities." [68]*

***(5) Luxembourg:** "[To] create sustainable partnerships with national, European and international partners" [87]*

***(6) Ethiopia**: "Coordinate regulatory approaches by collaborating with regional and international organizations, such as Africa Union and WHO, to harmonize international data submission and risk assessment and guidelines related to the licensure and/or approval of antimicrobial products, including vaccines and diagnostics." [53]*

***(7) Canada**: "The Joint Programming Initiative on Antimicrobial Resistance is an international collaboration of 26 countries, including Canada, aimed at coordinating research and actions of the diverse countries to achieve long-term reductions in resistance levels and better health outcomes. Current areas of focus include AMR transmission and developing or repurposing antibiotics." [66]*

***(8) Czech Republic:** "To coordinate the international cooperation of the Czech Republic in the areas of prudent use of antibiotics and antibiotic resistance prevention and control. The Czech Republic cooperates in particular with the European Centre for Disease Prevention and Control (hereafter referred to as ECDC) and World Health Organization (hereafter referred to as WHO) and participates in the relevant international projects such as the European Antibiotic Resistance Surveillance System (hereafter referred to as EARSS) and European Surveillance of Antibiotic Consumption (hereafter referred to as ESAC). The organization of the international Antibiotic Awareness Day (hereafter referred to as EAAD) is also part of the international cooperation agenda." [79]*

(9) The Philippines: *"The Philippines is also part of the Asian Network for Surveillance of Resistant Pathogens (ANSORP), which is a study group involving different countries in Asia in relation to AMR." [110]*

(10) Bangladesh: *"the health ministers of the member states of World Health Organization for South East Asia (WHO SEA) region met in Jaipur, India in September, 2011 and agreed to acknowledge the AMR as a major global public health issue, to institute a coherent, comprehensive and integrated national approach to combat AMR and sixteen other activities by signing to a charter of activities named as the "Jaipur Declaration"." [97]*

B. GLASS data analysis

1. AMR rates submission

In 2020, 66 countries figured on the list of countries in the GLASS online portal [113], 50 of which are included in our study. Out of these, 12 submitted data on *MRSA* resistance, 5 submitted data on *E. Coli* resistance, 27 submitted data on both, and 6 didn't submit any data (Figure 12) (Table 1). The six countries include: Cambodia, Canada, Nigeria, North Macedonia, the Maldives, and the USA. Whether there was no data submission or data were not made public is unclear. According to the WHO's 2020 GLASS report, these countries have responded to the 2019 data call [40]. Eight out of the 10 countries that don't figure on the GLASS portal are from the African region, and two from the Southeast Asian region (end of Table 1).

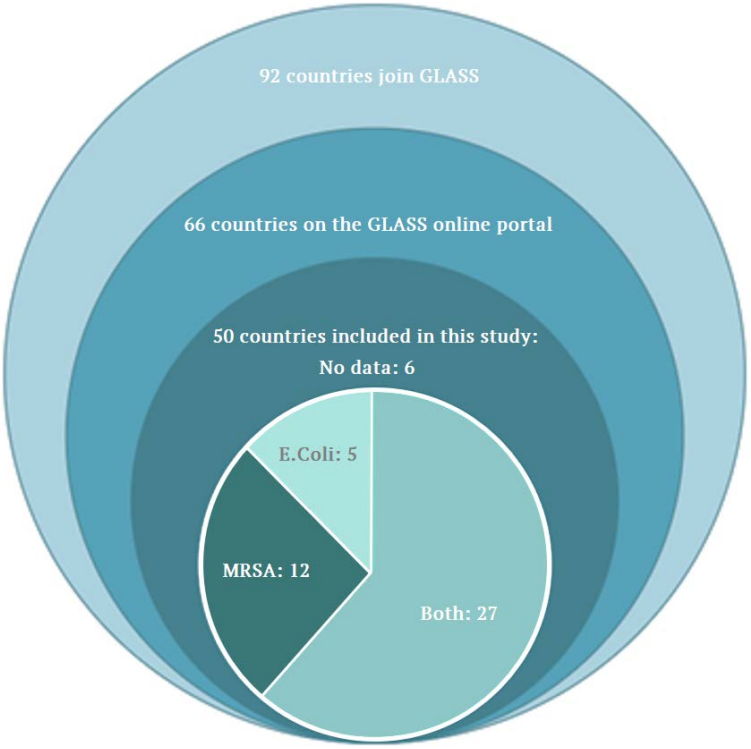

Figure 12: Organigram contrasting countries engagement in GLASS and data submission.

2. Proxies: *MRSA* in the blood, *E. Coli* in urine

Looking at the data available on our two proxies, we realize that they are partial and uncomprehensive. As mentioned, only 27 countries have submitted data on both *Staph. aureus* and *E. Coli* resistance rates. Very few of these have submitted complete Antimicrobial Susceptibility (AST) data of all antimicrobials included in the GLASS dataset (Table 2).

On the other hand, we observe high resistance rates of both *Staph. Aureus* and *E. Coli*. This observation is indiscriminate of regions and income levels. For example: 68% *MRSA* in Cyprus, vs 50% in the Philippines, and 79% In Egypt. And 60% resistant *E. Coli* in Afghanistan, vs 45% in Lithuania, and 54% in Sudan (Table 2). As high and alarming as these numbers are, we have to examine two more numbers to appreciate their significance: the total number of infected samples these rates as based on, as well as the percentage of unknown AST results.

3. Numbers of infections

A closer look at the numbers of infections reported to GLASS shows that these rates are to be interpreted with caution. The 68% *MRSA* rate in Cyprus is based on a total of 8 infections, while Egypt's 79% is based on 46. Afghanistan's 60% *E. Coli* resistance is based on 28 infections, and Lithuania's 45% is based on 170 (Table 3). Few countries have submitted five-digit numbers, those include: Argentina, Germany, India, Japan, Switzerland, and the UK, however; we would have to consider the infections/population ratio for them to be comparable.

I observe that the poor data submission trend concerns all regions regardless of income level. The source of infection is also often not indicated: 23 out of 32 *E. Coli* infection data submissions and 28 out of 39 *MRSA* infection data submissions are described as "Origin Unknown". This goes for Norway as well, which despite having robust registers has not indicated the source of its 4072 *E. Coli* infections.

4. Unknown AST results

The percentage of unknown AST results is the second number to consider when interpreting resistance rates to antibiotics. The GLASS portal indicates this using a color code as shown on Figure 13. Table 4 is a summary of the AST results of all antibiotics included in this study: out of fourteen, only two had complete or near complete data: Doripenem and Colistin at 0% and 15.4% >30% unknown AST results respectively. These two, however; are less commonly used. Popular antibiotics like Ciprofloxacin and Cefoxitin sported high numbers: 96.7% and 86.7% respectively, demonstrating that they are far from being routinely tested.

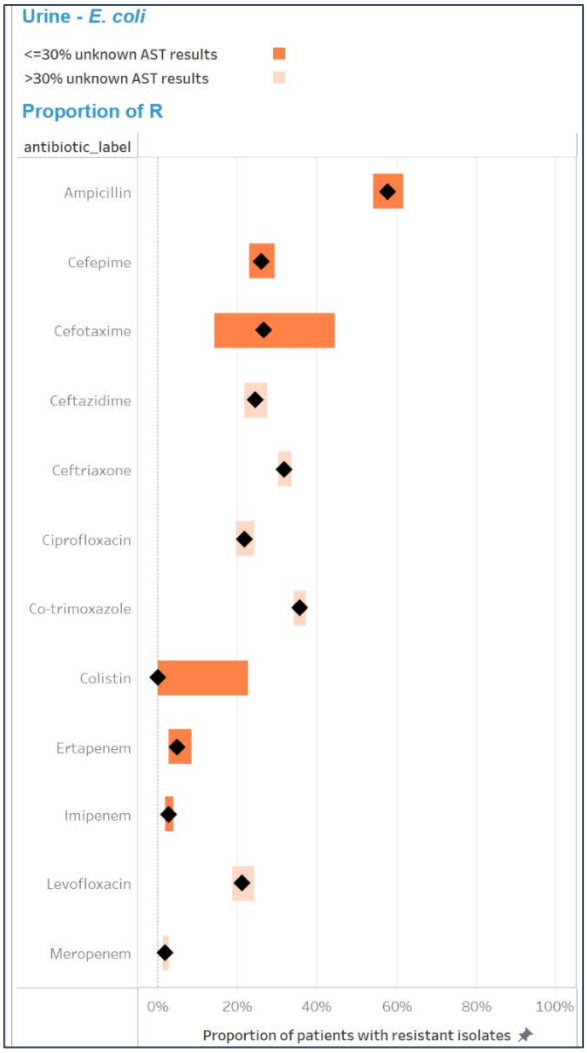

Figure 13: AST % results color coding on GLASS portal

Table 1: List of countries included in this study vs data available on GLASS online portal. Grey: not on GLASS portal

Country	WHO Region	Income Level	NAP start year	*MRSA* Data	*E. Coli* Data
Afghanistan	EMRO	Low	2017	no	yes
Argentina	AMRO	Upper Middle	2015	yes	yes
Australia	WPRO	High	2015	yes	no
Austria	EURO	High	2014	yes	no
Bahrain	EMRO	High	2016	yes	yes
Bangladesh	SEARO	Lower Middle	2017	no	yes
Brazil	AMRO	Upper Middle	2018	yes	yes
Cambodia	WPRO	Lower Middle	2015	no	no
Canada	AMRO	High	2017	no	no
Croatia	EURO	High	2017	yes	no
Cyprus	EURO	High	2012	yes	no
Czech Republic	EURO	High	2011	yes	no
Egypt	EMRO	Lower Middle	2018	yes	yes
Ethiopia	AFRO	Low	2015	no	yes
Finland	EURO	High	2017	yes	yes
France	EURO	High	2016	yes	no
Germany	EURO	High	2015	yes	yes
Greece	EURO	High	2008	yes	yes
India	SEARO	Lower Middle	2017	yes	yes
Indonesia	SEARO	Upper Middle	2017	yes	yes
Iran	EMRO	Upper Middle	2016	yes	yes
Iraq	EMRO	Upper Middle	2018	no	yes
Ireland	EURO	High	2017	yes	no
Italy	EURO	High	2017	yes	no
Japan	WPRO	High	2016	yes	yes
Jordan	EMRO	Upper Middle	2018	yes	yes
Lithuania	EURO	High	2017	yes	yes
Luxembourg	EURO	High	2018	yes	no
Malaysia	WPRO	Upper Middle	2017	yes	yes
Maldives	SEARO	Upper Middle	2017	no	no
Malta	EURO	High	2018	yes	yes
Myanmar	SEARO	Lower Middle	2017	yes	yes
Nepal	SEARO	Lower Middle	2016	yes	yes
Netherlands	EURO	High	2015	yes	no
Nigeria	AFRO	Lower Middle	2017	no	no
Norway	EURO	High	2015	yes	yes
Oman	EMRO	High	2016	no	yes
Pakistan	EMRO	Lower Middle	2017	yes	yes
Philippines	WPRO	Lower Middle	2015	yes	yes
Poland	EURO	High	2016	yes	no

North Macedonia	EURO	Upper Middle	2012	no	no
Saudi Arabia	EMRO	High	2017	yes	yes
South Africa	AFRO	Upper Middle	2018	yes	no
Sri Lanka	SEARO	Lower Middle	2017	yes	yes
Sudan	EMRO	Low	2018	yes	yes
Sweden	EURO	High	2016	yes	yes
Switzerland	EURO	High	2015	yes	yes
Thailand	SEARO	Upper Middle	2017	yes	yes
UK	EURO	High	2019	yes	yes
USA	AMRO	High	2015	no	no
Ghana	AFRO	Lower Middle	2017		
Kenya	AFRO	Lower Middle	2017		
Liberia	AFRO	Low	2018		
Malawi	AFRO	Low	2017		
Mauritius	AFRO	High	2017		
Tanzania	AFRO	Lower Middle	2017		
Zambia	AFRO	Lower Middle	2017		
Zimbabwe	AFRO	Lower Middle	2017		
Bhutan	SEARO	Lower Middle	2018		
Democratic People's Republic of Korea	SEARO	Low	2018		

Table 2: Summary of AMR rates available on GLASS portal.

Country	**Average resistance proportion of *MRSA* in blood**	*MRSA* resistance to Cefoxitin	*MRSA* resistance to Oxacillin	**Average resistance proportion of *E. Coli* in urine**	Average *E. Coli* resistance to C4G	Average *E. Coli* resistance to C3G	Average *E. Coli* resistance to FLQ	*E. Coli* resistance to Cotrimoxazole	Average *E. Coli* resistance to Carb	*E. Coli* resistance to Colistin
Afghanistan	**NA**	NA	NA	**60.78667**	NA	52.82333	NA	68.75	NA	NA
Argentina	**41.88125**	41.7277	42.0348	**14.77417**	10.56	13.45	23.08	40.94	0.145	0.47
Australia	**18.47**	18.47	NA	**NA**	NA	NA	NA	NA	NA	NA
Austria	**5.1143**	5.1143	NA	**NA**	NA	NA	NA	NA	NA	NA
Bahrain	**40**	NA	40	**19.05528**	26.09	27.72667	21.595	35.66	3.26	0
Bangladesh	**NA**	NA	NA	**44.11**	51.4	53.11	62.77	NA	9.16	NA
Brazil	**20.56**	NA	20.56	**19.275**	NA	8.3	34.93	33.69	0.18	NA
Cambodia	**NA**	NA	NA	**NA**	NA	NA	NA	NA	NA	NA
Canada	**NA**	NA	NA	**NA**	NA	NA	NA	NA	NA	NA
Croatia	**22.775**	24.86	20.69	**NA**	NA	NA	NA	NA	NA	NA
Cyprus	**68.1055**	36.21	100.001	**NA**	NA	NA	NA	NA	NA	NA
Czech Republic	**12.24795**	12.5237	11.9722	**NA**	NA	NA	NA	NA	NA	NA
Egypt	**79.59**	NA	79.59	**69.42125**	83.33	86.55	78.175	NA	29.63	NA
Ethiopia	**NA**	NA	NA	**48.72042**	50	62.22667	NA	81.79	0.865	NA

Finland	**2.075**	NA	2.075	**15.93333**	NA	27.26667	14.8	21.3	0.366667	NA
France	**12.0743**	12.5203	11.6283	**NA**	NA	NA	NA	NA	NA	NA
Germany	**6.444**	6.0866	6.8014	**10.699**	8.17	9.073334	15.095	21.13	0.026667	NA
Greece	**41.09**	38.767	43.413	**14.01067**	10.92	11.54333	21.96	24.93	0.7	NA
India	**56.43**	56.43	NA	**49.57833**	64.745	71.37666	73.135	61.57	25.28333	1.36
Indonesia	**38.203**	36.554	39.852	**45.69028**	43.94	63.70333	71.835	64.6	2.283333	27.78
Iran	**39.08**	39.08	NA	**51.138**	56.29	64.63	57.53	68.09	9.15	NA
Iraq	**NA**	NA	NA	**58.31933**	74.07	78.50667	56.405	75.49	7.125	NA
Ireland	**13.8615**	14.955	12.768	**NA**	NA	NA	NA	NA	NA	NA
Italy	**36.9895**	38.748	35.231	**NA**	NA	NA	NA	NA	NA	NA
Japan	**36.42**	NA	36.42	**17.09083**	13.9	18.35333	36.075	NA	0.035	NA
Jordan	**60.435**	48.48	72.39	**33.9574**	37.4	47.81333	49.2	54.37	1.41666	0
Lithuania	**9.299**	9.299	NA	**45.144**	66.36	73.83	15.44	70.09	0	NA
Luxembourg	**6.22**	NA	6.22	**NA**	NA	NA	NA	NA	NA	NA
Malaysia	**18.8395**	19.528	18.151	**16.71736**	14.71	21.04667	27.09	36.75	0.7075	0
Maldives	**NA**	NA	NA	**NA**	NA	NA	NA	NA	NA	NA
Malta	**22.08**	NA	22.08	**12.73194**	8.21	10.415	31.8	25.91	0.056667	0
Myanmar	**49.515**	55.61	43.42	**64.29134**	64.84	76.29333	80.14	79.18	21.00333	NA
Nepal	**41.195**	33.33	49.06	**43.70267**	57.56	59.70333	40.215	46.13	14.905	NA
Netherlands	**1.6227**	1.6466	1.5988	**NA**	NA	NA	NA	NA	NA	NA
Nigeria	**NA**	NA	NA	**NA**	NA	NA	NA	NA	NA	NA
Norway	**1.1326**	1.2706	0.9946	**8.101251**	NA	2.695	9.26	20.45	0	NA
Oman	**NA**	NA	NA	**28.20389**	53.05	47.17667	28.95	37.38	1.086667	1.58
Pakistan	**64.98**	NA	64.98	**51.17681**	76.14	74.94334	72.935	68.55	13.3325	1.16
Philippines	**50.85655**	50.8287	50.8844	**30.7325**	29.6	41.23	47.075	60.19	5.85	0.45
Poland	**10.9175**	14.938	6.897	**NA**	NA	NA	NA	NA	NA	NA
North Macedonia	**NA**	NA	NA	**NA**	NA	NA	NA	NA	NA	NA
Saudi Arabia	**48.94**	48.94	NA	**29.69347**	43.99	43.78333	39.43	47.55	2.0275	1.38
South Africa	**21.35**	NA	21.35	**NA**	NA	NA	NA	NA	NA	NA
Sri Lanka	**55.99**	55.99	NA	**31.88333**	NA	45.965	48.37	NA	1.315	NA
Sudan	**48.39**	48.39	NA	**54.20833**	NA	78.125	66.67	NA	17.83	NA
Sweden	**1.77665**	1.7989	1.7544	**4.833333**	NA	3.57	10.9	NA	0.03	NA
Switzerland	**3.68265**	3.9072	3.4581	**7.557777**	3.8	5.72	12.9	22.07	0.026667	0.83
Thailand	**10.3525**	12.429	8.276	**31.46861**	32.48	38.94667	59.29	54.6	2.405	1.09
UK	**10.4**	10.4	NA	**11.38467**	11.73	10.68	10.63	23.79	0.093333	NA
USA	**NA**	NA	NA	**NA**	NA	NA	NA	NA	NA	NA

Table 3: Numbers of E. Coli and MRSA infections and their origins

Country	*E. Coli* Infections				*MRSA* Infections			
	Community origin	Hospital origin	Unknown origin	Total	Community origin	Hospital origin	Unknown origin	Total
Afghanistan	28	NA	NA	28	28	NA	NA	28
Argentina	NA	NA	28	28	NA	NA	31567	31567
Australia	4093	821	NA	4914	5649	NA	NA	5649
Austria	NA	NA	2382	2382	NA	NA	478	478
Bahrain	645	143	288	1076	59	NA	12	71
Bangladesh	NA	NA	394	394	NA	NA	8	8
Brazil	253	530	77	860	15	138	13	166
Cambodia	77	104	95	276	133	31	210	374
Canada	NA	NA	NA	NA	NA	NA	NA	NA
Croatia	20	NA	NA	20	NA	NA	143	143
Cyprus	NA	NA	8	8	NA	NA	8	8
Czech Republic	NA	NA	387	387	NA	NA	1563	1563
Egypt	219	357	NA	576	17	29	NA	46
Ethiopia	13	NA	104	117	NA	NA	10	10
Finland	NA	NA	1494	1494	NA	NA	957	957
France	NA	NA	1264	1264	NA	NA	3095	3095
Germany	NA	NA	59131	59131	NA	NA	154	154
Greece	2044	29	3795	5868	11338	77	9733	21148
India	11175	4827	21826	37828	1861	2160	3178	7199
Indonesia	NA	NA	15	15	NA	NA	358	358
Iran	NA	NA	521	521	NA	NA	478	478
Iraq	1	2	22	25	1	NA	NA	1
Ireland	NA	NA	64	64	NA	NA	348	348
Italy	NA	NA	7682	7682	NA	NA	1166	1166
Japan	43511	35412	NA	78923	2112	1129	NA	3241
Jordan	14	NA	169	183	NA	NA	13	13
Lithuania	170	NA	NA	170	NA	NA	656	656
Luxembourg	NA	NA	492	492	NA	NA	38	38
Malaysia	200	303	1498	2001	253	51	775	1079
Maldives	NA	NA	NA	NA	NA	NA	NA	NA
Malta	107	NA	4	111	26	NA	1	27
Myanmar	3	NA	349	352	3	NA	349	252
Nepal	464	NA	796	1260	42	NA	280	322
Netherlands	NA	NA	1434	1434	NA	NA	2627	2627
Nigeria	NA	NA	NA	NA	NA	NA	NA	NA
North Macedonia	NA	NA	14	14	NA	NA	55	55
Norway	NA	NA	4072	4072	1277	NA	224	1501
Oman	NA	NA	119	119	NA	NA	1804	1804
Pakistan	NA	NA	775	775	NA	NA	2352	2352

Philippines	833	392	551	1776	1067	637	910	2614
Poland	72	3	157	232	NA	NA	254	254
Saudi Arabia	NA	NA	42	42	NA	NA	60	60
South Africa	NA	NA	650	650	NA	NA	744	744
Sri Lanka	722	NA	2	724	NA	NA	42	42
Sudan	NA	NA	18	18	NA	NA	32	32
Sweden	NA	NA	112	112	NA	NA	5948	5948
Switzerland	94274	6390	20249	120913	3824	485	1739	6048
Thailand	570	215	6	791	11	1	NA	12
UK	NA	NA	57770	57770	NA	NA	1932	1932
USA	NA	NA	NA	NA	NA	NA	NA	NA

Table 4: Summary of AST results data of antibiotics included in this study. Yes=>30% Unknown. No= <30% Unknown. NA= Not Available

Country	**Cefoxitin**	**Oxacillin**	**Cefepime**	**Ceftazidime**	**Cefotaxime**	**Ceftriaxone**	**Ciprofloxacin**	**Levofloxacin**	**Cotrimoxazole**	**Ertapenem**	**Imipenem**	**Meropenem**	**Doripenem**	**Colistin**
Afghanistan	NA	NA	NA	Yes	Yes	Yes	NA	NA	Yes	NA	NA	NA	NA	NA
Argentina	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	NA	Yes	Yes	NA	Yes
Australia	Yes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Austria	Yes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bahrain	NA	Yes	No	Yes	No	Yes	Yes	No	Yes	No	No	No	NA	No
Bangladesh	NA	NA	Yes	Yes	NA	Yes	Yes	NA	NA	NA	Yes	NA	NA	NA
Brazil	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA
Cambodia	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Canada	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Croatia	Yes	No	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyprus	No	Yes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Czech Republic	Yes	Yes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Egypt	NA	No	Yes	Yes	Yes	Yes	Yes	Yes	NA	NA	Yes	Yes	NA	NA
Ethiopia	NA	NA	Yes	Yes	No	Yes	NA	NA	Yes	NA	No	Yes	NA	NA
Finland	NA	Yes	NA	No	No	Yes	Yes	No	No	No	No	No	NA	NA
France	Yes	Yes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Germany	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	NA
Greece	No	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	Yes	Yes	NA	NA
India	Yes	NA	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	NA	No
Indonesia	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	NA	No
Iran	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	No	NA	NA
Iraq	NA	NA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA
Ireland	Yes	Yes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Italy	Yes	Yes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Japan	NA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	NA	Yes	Yes	NA	NA
Jordan	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	No

Lithuania	Yes	NA	No	No	No	NA	Yes	NA	No	NA	NA	No	NA	NA
Luxembourg	NA	Yes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Malaysia	Yes	Yes	Yes	Yes	Yes	No	Yes	NA	Yes	Yes	Yes	Yes	No	No
Maldives	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Malta	NA	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	Yes	Yes	NA	Yes
Myanmar	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	NA	NA
Nepal	No	No	No	No	No	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA
Netherlands	Yes	Yes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nigeria	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Norway	Yes	Yes	NA	Yes	Yes	NA	Yes	NA	Yes	NA	NA	Yes	NA	NA
Oman	NA	NA	No	Yes	No	Yes	Yes	NA	Yes	No	Yes	Yes	NA	No
Pakistan	NA	Yes	No	No	No	Yes	Yes	No	Yes	No	Yes	Yes	No	No
Philippines	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Poland	Yes	No	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
North Macedonia	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Saudi Arabia	Yes	NA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
South Africa	NA	Yes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sri Lanka	Yes	NA	NA	NA	Yes	No	Yes	NA	NA	NA	Yes	Yes	NA	NA
Sudan	Yes	NA	NA	Yes	NA	Yes	Yes	NA	NA	NA	Yes	Yes	NA	NA
Sweden	Yes	No	NA	No	No	NA	Yes	NA	NA	NA	No	No	NA	NA
Switzerland	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	No
Thailand	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No
UK	Yes	NA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	NA
USA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	26/30 **86.7%**	24/30 **80%**	19/25 **76%**	26/31 **83.9%**	21/30 **70%**	24/27 **88.9%**	29/30 **96.7%**	13/18 **72.2%**	24/26 **92.3%**	12/17 **70.6%**	24/29 **82.7%**	24/30 **80%**	0/5 **0%**	2/13 **15.4%**

C. Interviews

I present our results under three main themes identified from the analysis of participants response. The first examines the place of AMR surveillance and the challenges that face the implementation of National Action Plans, as well as previous success and shortcomings. The second theme discusses the place and the narratives surrounding international collaboration and the problems with data sharing. And the final theme touches on the influence of metrics in shaping the AMR narrative.

1. Implementation challenges

a. Importance of surveillance

Experts that participated in this study reflected on the importance of antimicrobial resistance and use surveillance. Data collection was described as a primary tool to forge and target future action plans, as one participant stated:

> *"You have to know first of all, resistance patterns on important pathogens but you also should know of course how much antibiotics you are using and what type of antibiotics you are using. if you don't know that, you wouldn't know if you are bad or good or where you are. So you have to have a certain basic knowledge, and that's why GLASS is so important now because if we can get a global baseline, we would also know where to go."*

However, one participant felt that, when it comes to implementing and assessing National Action Plans, there tends to be a greater focus on AMR and GLASS data at the expense of other, more informative indicators such as education, AMU optimization and governance, which blinds to the broader picture of AMR. They state:

> *"AMR has about five pillars. [We] focus on a particular pillar, ignoring that we need to look at the holistic picture: What is happening in the area of awareness and education, in the area of optimizing use of antimicrobials, in infection prevention and control, water, hygiene and sanitation, in governance and multi sectoral collaboration, in research and development… Then we have one area, GLASS data call… if we were to give them equal percentage then GLASS data call or surveillance and lab capacity is 20% of a 100. And so for me that looks at a specific system. It does not tell me holistically what the AMR program is in that country."*

b. Policy development

i. Generic NAPs

National Action Plans are challenged from conception. The 2015 Global Action Plan on AMR served as a template and a guiding beacon for many countries in the process of developing their own. This has led to the generation of documents that the IACG describes as boilerplates [6]. Participants reflected on the danger copy-pasting poses to the success of NAPs, as one stated:

> *"One danger is to copy paste… To copy paste is not the way to do it because […] the country developing National Action Plans needs to have ownership to their own plans, and they need to see that it's beneficial for them."*

Participants identified situational analysis as a crucial steppingstone to develop well-functioning NAPs, without which it is not possible to identify the topics and issues most relevant to the country's AMR situation:

> *"If the situational analysis that is done is done effectively, then the plan itself […] will be inherently different. […] You want to make sure that you are identifying issues that are inherent to your own countries, your own systems. And then using that to develop an action plan that will help you resolve those issues and problems that you have identified."*

According to one expert, misunderstanding the concept of One Health as a one-size-fits-all is another component that explains the genericism of NAPs. This knowledge is crucial to develop solutions that are national and context driven:

> *"One of the contexts under which we implement and help countries to develop the National Action Plan is this concept of the One Health approach, but if you understand that concept very well, then you know that the One Health approach is not a one-size-fits-all… I think that when you see [countries cutting and pasting] it tells you maybe there is no understanding of what needs to be done. [There needs to be] more capacity building [to ensure that NAPs] are very context specific and speak to the national issues and problematics."*

Participants are nonetheless hopeful about the future, as one expressed optimism that the future plans will have learnt from the past and will be more adapted and localized:

"Now that we have five to seven years' experience with these action plans, I'll guarantee you that the next ones will be much more localized and adapted but still keeping AMR higher up on the political agenda."

ii. Policy environment

Participants remarked on the importance of considering the context in which a policy is being implemented. Their opinion was that no policy exists in a void. It only succeeds when it is in harmony with pre-existing policies, parallel interventions, and the public health philosophy and ecosystem of the country. One participant articulated the following:

"In the UK in particular there have been some pretty impressive gains in terms of reducing antibiotic prescribing in Primary Care, but some of the reasons for that are that there have been other interventions on top of the action plans. So the action plan does not stand alone. The action plan, like any policy, is a document that is in concert and in conversation with many other interventions. [...] What you have is an action plan as a starting point or as a directed effort that then interacts with the rest of the policy environment or ecosystem in order to effectively work as a prioritization exercise. So your action plan prioritizes where your other priority interventions will sit."

c. Political dynamics

Political dynamics were described by all participants as pivotal determinants of the level of engagement and action on AMR in any given country. Discussing the example of Norway, one expert stressed the importance of political will in recruiting various ministries and anchoring AMR on their agendas:

"Political will is important, [especially,] broad political will, which, for the Norwegian action plan, was anchored in four ministries. It was not only the Ministry of Health, it was also Food and Agriculture, Fisheries and Environment and Health. Also now for the next one that we are planning to develop we also have the Ministry of Foreign Affairs on board. So having issues like AMR as a core element in many political activities is important to spread the interest and the feeling of urgency."

Participants described poor governance and difficult coordination as main challenges to NAP implementation. The cross-sectoral nature of AMR requires the investment and collaboration of several disciplines to achieve results, an arduous task in the absence of sufficient governance mechanisms and the presence of accountability and transparency vulnerabilities:

"One of the major challenges [22 African countries] outlined was that governance and coordination is very difficult. Because AMR itself is very complex, in the sense that it is multi and interdisciplinary. [...] It is not just a human health issue or an agricultural issue, but also an environmental issue. So you have actually at least three or four different sectors crossing each other. And so you must now find a way have a common objective and move and implement together. [Otherwise] you are not addressing AMR."

Good governance requires political buy-in and strong leadership. Politicians must be made aware of the challenge AMR poses and their engagement recruited to ensure the allocation of resources necessary to implement policies. One participant explained:

"Governance and multi-sectoral coordination become very challenging if there is no leadership. Countries that have a primary interest, right from the top of the leadership seem to do well in terms of implementation because the highest level of the government are implicated. In countries where it seems as if the government is lagging in terms of the support for this agenda, you begin to see that the governance is weak and so the implementation itself is not that strong. [This leads to bottlenecks that represent a serious challenge in policy] in terms of financial and budgetary ramifications, and making available the kind of infrastructure that needs to be put in place for effective implementation across all sectors."

The same participant referred to Ghana as a success-story of a country that benefited from strong leadership that trickles down to subordinate ministries and translates into action:

"A country that has been doing particularly well [is] Ghana, for example. The AMR agenda finds itself at the top, at the highest level of the government, which is the president and the Prime Minister's Office. This is very important, because it means that the President himself recognizes this as a very important priority, [therefore] his ministers and those who are in charge of implementing his policies will also take that seriously."

One way to obtain political buy-in is through information sharing, as sometimes the issue is to do with ignorance and lack of knowledge on the extent of the problem. One expert on antimicrobials commented on the swift action taken by Dutch policy makers to reduce AMU in animals following a report by the European Medical Agency (EMA):

"If you look at the Netherlands, they have a good system and they use little antibiotics and they have good resistant patterns and so on but a couple of years ago they got a report from the EMA on

antibiotic use in animals. [...] the first report showed that the Netherlands uses an enormous amount of antibiotics. The politicians didn't know. [However,] by showing the data [...] they turned around very quickly and they reduced their antibiotic use data on animals quite a lot."

Political buy-in is, nevertheless, hindered by political vested interests. Public health concerns are at the mercy of the political agendas of ruling parties, insofar as vested interests have the ability to stifle action and redefine priorities. One participant explained:

"If governments actually made decisions based on moral correctness, we would not be where we are. So pragmatically as a policymaker or as a government [...] we make decisions according to economic realities that land with the political party in power of the day, in a way that can be conceptualized as providing impact and return on investment within the length of time that any political party is expecting to stay in power. So that the impact of those decisions can be brought to the attention of the voters before the next election."

d. Economic dynamics

Lack of resources was pointed out by many participants as a main challenge facing NAP implementation. They describe insufficient budgets as a main reason for not achieving the goals outlined by NAP documents. A participant from Norway stated:

"There's still lot of a countries who have a NAP but do not have the money to do anything about it. Here we don't have that much money. I mean, we did the National Action Plan. There was money put into different parts of the system but we wanted more of course. So there's a lot of things we haven't done yet."

One participant pointed out to poor budget commitment in the Tripartite AMR Country Self-assessment Survey (TrACSS) which monitors country progress with NAP implementation:

"In the 2019 to 2020 TrACSS, they have in fact an item which spoke to whether or not a country had fully financed the National Action Plan, and it turned out that only one out of five countries could respond [that they have a fully financed plan]. So one out of five is really quite obviously, modest, to say the least. We're actually not very good at all. In fact only 40% of National Action Plans even had an operational budget."

Furthermore, poor planning is compounded by short budget cycles wherein short-term budgeting prohibits policy maturation and hinders sustainability, as one participant explained:

"When budgeting, [many countries] don't plan more than three or five years to have a development project and get promises for financing [for no] more than three years. It's really difficult. And if you are to achieve sustainable results, you have to engage for at least 10, 15 years."

However, another participant argued that lack of resources ought not to be used as an excuse for weak action, and objected to the common use of the term "limited resource setting":

"In the context of Africa, people like to talk about limited resource setting. I don't like that word very much because when you talk about limited resource setting, what do you mean? No country has excess or too much resources. So we actually need to contextualize that in terms of what we are really trying to say. There will always be scarce resources. The question is how do you use these scarce resources to get a maximized impact?"

The same participant argued for the necessity of leveraging existing recourses and mainstreaming AMR actions into pre-existing programs. They contended that innovative approaches are more impactful in a context of scarcity than the allocation of new funds to vertical programs:

"AMR is not a health issue, it's a development issue. Because it crosses different systems and sectors. [...] For example, if you are already implementing WASH[3] interventions, you are already doing something related to AMR, you just need to leverage those systems. [The question is:] how do you effectively use the resources [and systems] that you actually have? This does not mean that additional funds are not necessary, [but] the scarcity of resources demands that you be innovative in the approaches that you are using in addressing AMR, which means not creating new [or vertical] programs, but doing what we call mainstreaming into those programs and systems that are already existing."

This opinion concurred with that of another participant who affirmed that much can be achieved in resource-poor settings when consumers trust their health care providers:

"As we have seen now with the pandemic, it's not necessarily the richest countries that have the best preparedness because there are other factors. You can do it the smart way, instead of the expensive way. [For example,] comparing Palestine and Israel regarding vaccinations. Palestinians, although they don't trust the government, they trust the health care people, they trust the vaccines, so the vaccination coverage is really good. Whereas in Israel it's not so because you have, as in many Western countries, alternative movements questioning whether this is the good thing to do or so on.

[3] Water, sanitation, and hygiene

So, when looking at the country perspective, or the health system perspective, you need to include things like trust, in government, in corruption and so on. So it's so many other factors that are also important and you can achieve a lot even when you don't have too many resources."

e. Stakeholders buy-in

In addition to political buy-in, participants stressed the importance of other stakeholders' endorsement in the success of AMR Action Plans. These stakeholders include health experts, health professionals, as well as the public.

The complex nature of AMR can lead to a divide between experts and professionals that manifests from the early stages of planning. One participant delineates three contributors to this disconnect. The first is disagreement on health priorities in general and priority actions on AMR in particular, they state:

"Buy-in is a very amorphous concept but you need buy-in from everybody involved. A challenge is the complex system. [First,] do professionals and the experts in this area agree that the priorities in the action plan are the most important priorities for AMR. Do experts consider that the emphasis placed on AMR is proportionate to the emphasis that ought to be placed on other areas of health?"

The second component is involvement in the policy development process, wherein buy-in from professionals is acquired by consulting them. Thus who has access to this process eventually defines the shape and priorities of the strategy. They continue:

"[Second,] how are policies created? Who has access to the consultation process and what that access looks like is very important."

The third component is the decline of trust in public institutions which cuts across country income levels. Professionals are tasked with implementing action that they may believe is motivated by vested interested of governing bodies instead of public interest. They conclude:

"[And third,] trust in public institutions. So trust in public institutions is waning in many countries in the Global North. That is not untrue in the UK as well. So, do staff on the ground who are tasked with reducing inappropriate prescribing believe that the reasons behind that are valid? Do they believe that the governing bodies that are involved in that process have the best interest of everyone? But the point is all of these things exist in an ecosystem, a complex ecosystem in which they're being asked to make changes."

Acquiring the buy-in of healthcare professionals is made easier by the success of previous interventions and pre-established systems. One participant illustrates this notion with an example from Norway:

"When it came to the specialist health care system, [the action plan] was unexpectedly well received. […] when it came to establishing stewardship programs, for example, most hospitals were very eager to do that and they hired specialist nurses to follow up and to establish these systems. And it was based largely on our previous success related to tuberculosis coordinators, which has been a system they've been running in Norway for many years."

They contrast the seamless success of the action plan in the specialist care sector with the rocky implementation efforts in the primary care sector. They attribute the latter to poor information channels and collaboration, the non-standardization of information technology systems (IT), as well as the diverse nature of services provided by the primary care sector. All of which made achieving the action plan objectives more difficult:

"[There was already an] established platform for collaborations and continued collaboration with the specialist health care. […] Primary health care services are more diverse. They are not standardized in the same way for IT systems as others are, and they are harder to reach. I think the information channels and the tight collaboration that were already established were special. Also, previous successes and sharing of our results build up a trust into following up and understanding the importance of these actions. And I think that is kind of more obvious within the specialist healthcare services than it is in the primary and dental services."

Another participant made the case for leeway in healthcare practice as a tool to acquire professionals' buy-in and break down the tensions that may arise between regulators and practitioners. They explained:

"One of the things [regulators] gradually came up with was to say: Okay, these are the guidelines for antibiotic use in our hospital, if you want to deviate from the guidelines you would need to explain why in the patient case notes. You have to make a more conscious decision to argue why you are deviating from the guidelines. Then you give the specialist their freedom, but it's a little bit more effort and more work for them. So that's trying to make the guideline choice the easy choice, [all the while] giving them the freedom of deciding."

Finally, endorsement of the public is crucial to the success of any action plan. This is obtained by fostering trust and awareness through years of repeated action and consistent intervention:

"It's for all stakeholders in society from patients, doctors, politicians or health authorities and also private sector. They need to agree and understand this together. We've had the same process in Norway, we have spent years and years and years making people understand why this is important. And that's why now in Norway you see that parents come and they will say I don't want to have antibiotics for my child."

"to continuously do intervention on this because I mean if you don't remind people, they will forget. That is with interventions. You have to continuously remind on antibiotic resistance: remember that you should use the most narrow-spectrum one, the most targeted antibiotic, and have time..."

f. Social and cultural dynamics

Implementation of AMR action is challenged by the socio-cultural constructs of both care providers and consumers. Participants describe a pressure to prescribe born out of fear of mis- or undertreatment and its repercussions, both on the patient and the practitioner's personal and professional life:

"[The consequences for practitioners] if they prescribe an antibiotic in an unnecessary way are very low, but the consequence if they don't prescribe an antibiotic and it turns out that the patient has sepsis or subsequently die from the lack of antibiotic is medical negligence. They're not convinced that their employer and the National Health Service in the UK would support them in such a case, [not to mention] the potential loss of practice and their license. [...] So they are making decisions, not just based on what that must or must not be done in an AMR policy world, they are making decisions based on what they must and must not do across their practice of Medicine."

Contrary to the common narrative, low-income countries have no monopoly on overtreatment as it is a question of mentalities and attitude in healthcare across the board. One participant shares:

"[My American friends] consume tons of antibiotics. So it's not only in low-income countries, it's more the attitude and how healthcare is set up. And in the US, you get sued if you're a doctor and you don't treat it, so it's a huge overtreatment in the US."

One participant highlighted the importance of adapting interventions and solutions to the sociocultural context of the target audience, as well as involving social stakeholders in their implementation. They illustrate this idea with two examples, the first on how Ghana reached out to

the church to secure buy-in and spread AMR awareness, and the second on adapting hand washing messages to include sand instead of soap in communities with poor access to commodities:

"In Ghana, for example, when they were developing their national action plan, they reached out to the Christian community, because they understand that within their culture, this is a very important block that you also must consider and that they have an important stakeholder."

"One of the exercises I have been pushing with my colleagues in the communications department was to develop videos on the hand washing techniques and all of that. I remember a colleague in the communications department telling me: "my friend, you know, we cannot just be using soap because in some communities, and they don't even have soaps, so we might actually have to find what is realistic to that community", which in some cases was sand, and how that sand is used in terms of hand washing, and make sure that the effect is similar to the same effect you might have with soap."

The same participant made the case for what they call public health marketing: the creation of activities and messaging that promote AMR awareness in ways that match big brands' reach and reception:

"We also need to understand how to get information, such as AMR information on hygiene and sanitation, to people in the same way Coca Cola, Microsoft, and Louis Vuitton can get people to use their brand. [...] I call it public health marketing, public branding, we need to position ourselves and the products which are the messaging we are putting out there in a way that is receptive to people and we have ignored the evidence-based approach in that area."

g. Focus on downstream solutions

Participants identified NAP's focus on downstream solutions as a main challenge to their success. They view upstream intervention that targets the determinants of AMR as more deserving of the spotlight and resources that IT solutions, diagnostics tests, laboratory capacity and technology. One participant elaborates:

"If you think about all of the different facets of a NAP and interventions that we're talking about when we talk about AMR: IT solutions, diagnostic tests, technology in general, those are downstream, by which I mean they're close to the moment where the prescription is given. And not upstream, like health systems, strengthening or improving sick pay or sick leave rights for workers or improving health more broadly, investing in public health measures that decrease obesity or provide people with housing that isn't damp, which doesn't allow them to then get asthma and it doesn't require them to

have multiple antibiotic prescriptions when they then fall ill due to an upper respiratory tract infection. […] Even if you have the world's best IT systems, […] then you're slightly better able to manage prescriptions for people who are already in the healthcare system and are already at the decision point where they may or may not need an antibiotic. [But] that is so far down the line from where you need to be thinking about in terms of the level of change that needs to happen for AMR to actually reduce."

They argued that AMR strategies and interventions must be context aware and adapted to the immediate needs of the country or region:

"So I'm certain in many low- and middle-income countries, it doesn't help that the doctor gets a popup window on the screen when he prescribes an antibiotic that's not going to help. But it may help in some settings. So it's really complex, and that's why I think it should be adapted to each single region."

Another participant stressed the need for countries to adopt systems that are affordable and easier to manage and mainstream, instead of seeking resource-hungry technologies that may not be suited to their context. They illustrated this notion with an example on PCR machines:

"You might be saying that we should use a PCR machine and that country does not have a PCR machine. What other things can replace that? Don't simply copy and paste and say instead of two PCR machines, we might try to afford one. Meanwhile, you do not even have somebody who can actually use the machine, [let alone] analyze the sequencing results afterwards."

Participants raised two points that attempt to explain this focus on downstream solutions. The first is a choice made by wealthy high-income countries to subsidize that type of intervention at the expense of its upstream counterpart:

"The types of interventions that are promulgated by high income countries are ultimately not going to solve the problem. We rely on expensive technology and providing subsidies to multinational pharmaceutical companies and medical diagnostics companies to solve the problem. That is so far downstream that there'll be tons of emergence and transition and increased burden of AMR all around the world in areas where such technologies are not affordable or a reasonable use of funds that we will effectively create a never-ending problem."

The second is an element we already touched on: poor leadership and lack of awareness of the drivers of AMR:

"We want to ensure surveillance and lab capacity and all of that but sometimes even the politicians themselves do not understand what AMR is. Even the leaders who are supposed to be making the policy decisions do not understand. Yes, they are happy to take money to build lab [and] surveillance facilities, but if you don't provide that understanding and education and that awareness in a robust way, how do you ensure sustainability?"

h. Regulation and enforcement

Many participants praised the role of regulation in ensuring the success of AMR action and the reduction of antimicrobial use. A participant described the role of the Norwegian drug regulatory office in restricting antimicrobial circulation:

"I think regulation is really important. If you don't have that, then the pharmacists will sell antibiotics if there is no punishment. Actually I think one of the things that was important for Norway was in the seventies we had a drug regulatory office who are really strict and they said that if a new antibiotic and a new broad-spectrum antibiotic was not necessary, it wouldn't be taken into the market... I think it started there and then from that on, we kept it. so regulation is very important, in my mind."

However, while discussing the sales of antimicrobials in the black markets, one participant rejected brazen law enforcement as the solution. In their view, raising down black markets is but a symptomatic treatment that ignores the aforementioned development and social issues of poverty and unemployment that drive the behavior. They explain:

"I say how do you enforce it? There is no employment, and if the government were to try to enforce this, these people will not be able to feed their families. Is the government prepared to give all these 1000s of people jobs the next day? It has been tried before. This [black market] was raised down some years ago, but it sprung like a mushroom later on. And so some governments understand that this is not an issue they even want to tamper with because we are talking about people feeding their families. [...] when you are trying to provide a solution, make sure that you are also providing a solution in terms of how they are going to deal with the social issues of poverty and all that they might face after that. So there is a complex dynamic that is taking place here."

They further furnish their point of view by highlighting the access and excess dilemma, contending that, in low-income settings, AMU reduction efforts cannot begin without improving the availability and access to medication in hospital institutions:

"I can go to any street corner in this country in Congo, where I am in Brazzaville and I can buy as much antimicrobials as I want, unregulated. It might be effective, but it might be a sub lethal dose from the black market. [On the other hand,] in Africa, if you go into some hospitals in the first place, you will not have any medicines, [...] the only antibiotics they might have are macrolides, nothing else. And so for everything, even for the things where they do not need macrolides, they're [being used]."

i. One Health challenges

Some participants expressed that there is too much of a focus on human health when addressing AMR and that not enough is being done to tackle the environmental and animal component:

"Many are aware and people who are in this field are aware [of the importance of One Health]. But of course we are in boxes and very many of those who work in the human part think that the human part is very important and they wouldn't know what is happening in the animal part whether they like pouring antibiotics out in the fisheries in India for instance."

Speaking on the Norwegian experience, one participant hoped that the future actions will be more informative on the state of AMR outside human health:

"What is the consumption in agriculture and in animals? What is the spread? Which way does it go? Where does it spread and what spreads? And also, what are the differences in cities and rural areas in polar and temperate areas or tropical areas? so it's going to be more hopefully a bit more pinpointed to what are the challenges of these sections."

One participant remarked that One Health can have different definitions that vary with the context. They offered a definition that steers away from the typical tripartite of human, animal, and environment to encompass social, cultural, and anthropological determinants:

"Do we really understand what we mean by One Health and what it means in the afro context? [...] the definition for us might be very different. Because for me these social determinants, cultural determinants, [and anthropological determinants] are very important to what we do. Especially if we want to get buy-in."

However, we noted a divide when one Norwegian participant contended that, au contraire, research on One Health topics has become too broad and consumed by micro-concerns. They elaborated on the idea:

"When it comes to financing research activities, it may be time to revise the thought a little bit. First of all, the vast majority of infections in humans, we pick up from other humans. It seems a little bit unbalanced now that to treat a VRE[4] outbreak in hospitals or a challenge in hospitals is going to be compared when it comes to financing to someone searching for a special resistance gene in a pond, in a lake somewhere or in a special part of agriculture. So I think One Health has become too broad when it comes to research activities. […] In order to focus One Health, we need first to know which organisms are relevant. We know Tuberculosis and Gonorrhea are not relevant and we know that Salmonella and Campylobacter are relevant, but which organisms of Klebsiella and E. Coli are relevant. […] So there are so many uncertainties related to One Health activities that I think it's becoming too big a bag with very interesting projects, but obviously some more relevant than others and that is a problem I think for a lot of scientists trying to set up new systems."

They continued to question the pragmatism of One Health Surveillance, stating that any additional work must be justified and its results utilized:

"We don't know if we can use [One Health surveillance] for anything, we don't know if it's needed. We do know it would be a lot of work, we do know we can do it. But we don't know if we need to do it. So there are many things we need to find out before we really get going into at least the surveillance part of health."

j. Data, for whom?

In the same vein, other participants pointed that AMR data collection is laborious and requires strong commitment and resources from countries. Data must be actionable and geared towards informing local policy development, as well as made to directly benefit the local health systems instead of catering to abstract demands of a global audience. One participant illustrated this notion with their experience in the Maldives:

"If you have digital surveillance, you do have to ask who's having access to the data. So when we went to the Maldives to consult on their national action plan, we found that they had many struggles with the GLASS system, because they were entering all the data and it was growing up and going away to national funders, and donors got to be very happy that they are getting all this access to this data. But in terms of the systems that they had, that they could use on the ground on a daily basis, they didn't feel as though they had ownership of those data. So actually, who you're doing this work for, and

[4] Vancomycin Resistant Enterococcus faecium

why? and especially, are you doing it for a global health security audience? Or are you actually doing it for people to benefit from their own data? is a really important question when you're asking already stressed health systems, especially in low-middle income countries to perform additional labor for high income country funders and donors."

This sense of nonownership indubitably challenges countries' motivation to perform quality AMR surveillance. The objective is then: "let's share something on GLASS", instead of: "What can we do with our data?"

"How does that GLASS data have countries put in place context-based policies? Because for me, data [is not supposed] to go and stay up there. I would prefer that a country uses its data in an actionable way to address the issues while also submitting data to GLASS. Because [you want] that data to have an impact on the ground and in the lives of the people to which that data is supposed to be speaking. Yes, we need that data for research. We need that data to inform all the policies or to tell us what is happening globally, but what does the data do for the individual countries on the ground?"

k. Wars and geopolitical conflicts

Protracted conflicts and aggressions around the world disrupt health services, damage infrastructure and force governing bodies to revisit public health priorities. Issues like AMR are then relegated to the backburner in favor of more pressing and vital problems. One participant mentions his experience with Palestinian authorities:

"When we discussed this with the director at the Ministry of Health in Gaza, we presented them the concept of having a national action plan. For example, on antibiotic use, prescription restrictions and so on. And he said: "yes, this is all very well but right now the mentality here is not focused on this. It will not succeed". They are extremely realistic people, having to deal with extreme situations: being incarcerated, two million people in a small piece of land and lots of aggression and so on."

Action plans on AMR are further hindered by restricted access to resources caused by taxing aggression, physical blockades, or legal embargos, all of which creates a series of logistical obstacles that cripple implementation. The participant illustrates:

"Gaza saw a huge outbreak of viral meningitis, which doesn't need antibiotics. What the doctors told us was that almost all [patients admitted to the hospital] had been to the pharmacy and received antibiotics because of fever before admission. So it was almost impossible [to detect whether this was vital or bacterial] because you have covered up for any bacterial cause. They were really good with

spinal punctures [...] but they couldn't grow them normally [on plates in microbiological labs]. What they should do then is a PCR [test]. But the PCR wasn't readily available in Gaza because of restrictions by the Israelis [...]. It's a strange place because it's one of the best educated populations in the Middle East. They have high standards of universities, well educated, very little resources because they're incarcerated. So it's a difficult situation for them. But even when we helped them set up a PCR, they didn't have resources to buy the reagents and also the Israelis have very strict restrictions on what kind of chemicals you're allowed to import into the Gaza Strip."

2. International collaboration and reporting:

a. Importance of international collaboration

Participants agreed that international collaboration is crucial for tackling AMR due to its borderless nature. Globalization has made it impossible for countries to exist in isolated sterile bubble, hence the need for concerted action. One participant considers:

"It's absolutely necessary. It's a bit like climate change that we all need to chip in and work together. Because the world is so interdependent, when we travel, we import foods, products back and forth all the time. So, one country cannot live in isolation from the others, and if you have a high antibiotic resistance pressure in some countries, it will affect other countries as well. So we need to work on this together and to then have organizations like the WHO and OIE and FAO working on guidelines and the framework for National Action Plans. And then you would need to assist each other in implementing that in various countries."

Another participant emphasized this point by pointing out that resistance can be imported as well as exported, as is the case in Norway:

"Many of the AMR challenges we see in Norwegian health care services today originate from abroad, so we have imported a lot of our AMR. [But we also] produce AMR in Norway. For example, we have a case of a special clone of Neisseria Gonorrhea which was recent in Norway, we have seen that it has been exported from Norway, so these issues need to be solved internationally."

b. The collaboration bubble of high-income countries

Stressing the importance of international cooperation, one participant made a point of listing the various collaboration initiatives that Norway takes part in. I couldn't help but observe that all countries involved were northern, developed, and of high-income:

"I think [international collaboration] is the most important thing. AMR is an international problem that needs to be solved internationally. And what we are seeing internationally now is in this field, we are much more colleagues than competitors. And sharing our experience is becoming a very important part now in international collaboration. So in the Transatlantic Taskforce on AMR where Canada, USA, the European Union, UK and Norway participate, we are sharing our successes and shortcomings in these action plans to try to help each other find out what worked here and why, etc. And we also have the Nordic Dimensions on AMR, which is a collaboration between the Baltic States, Russia, Nordic states, and the European Union, where we do pretty much the same. We try to help each other and of course, the transfer of technology goes largely in the eastward direction."

When prompted on this bubble, the participant explained that the reasons behind this collaboration pattern can be traced to similitudes of infrastructure, challenges, and access to resources. They added that it was necessary to build knowledge that would eventually be streamed to other countries, as well as shared with global organizations:

"When it comes to the top four, which is the US, Canada, EU and Norway collaboration, it's a collaboration which has been set largely because we have similar infrastructure, we have similar challenges and we see that we need to share our efforts. It does not mean that we should not collaborate in other settings with other countries, which of course we do. But at some stage, it's difficult to improve our modeling techniques, our statistical techniques, our sequencing and microbiome studies if we don't collaborate with other nations with similar infrastructure and challenges. So that being said, this is all to build our competence in order of course to share elsewhere, like we have been doing: building public health institutes in other countries like Palestine and Malawi, and that we are also collaborating in projects and we are supporting the WHO's work."

As a result, high incomes countries are seen as leaders in the global effort to reduce AMR. Along with global organizations, they set its standards and measures of success:

"I think [the role of HICs and global organizations] is important. It is really important because they are the ones who can in a way set a global standard, I think. Of course, the developed countries have their own way. We have data, in Europe you have all the data. In other parts of the world, they do not or they may have but they may not use the same methods and then you cannot compare."

c. Power dynamics in AMR

This theme emerged in all conversations. Power dynamics, or how the politic and economic weight of some countries influences decisions and impacts the development of NAPs and their focus. Global interactions and narratives decide the flow of power, which stakeholders have a say, and dictate terms of engagement that are contingent on being a donor or a donee.

One of the ways in which these dynamics manifest is the perception of the AMR threat as a global health security problem, rather than a social justice problem that would be costlier and much more challenging to solve, as one participant remarks:

> *"I believe that AMR is a social justice problem, like poverty reduction or quality of living or standard living standards problem. But is that a harder sell for resource-constrained and increasingly sort of nationalistic governments in the Global North? Yeah, it is a harder sell. So framing it as a global health security problem, whilst very pragmatic, might be the least worst option for now."*

It terms of action plans' development; participants believe that global funding can skew the priorities of the receiving country, as the conditions attached to such backing generate results tailored to the benefit of the funders instead of the funded:

> *"The funding conditions for things like additional labor, perhaps in surveillance and perhaps elsewhere, can resemble tied aid from high income countries to low-income countries. And we know all of the problems that were engendered with tied aid when it comes to skewing the priorities of a nation to meet the preferences of the funder."*

These dynamics further clarify the genericism observed in NAP documents: donors are eager to advertise their accomplishments and receiving countries are eager to oblige, making copy-pasting the easiest way out:

> *"We all know what needs to be in place. We can use the checklist from WHO and others on what should be in place, but the easiest way out is to just a copy paste, as you say, and say this is the plan and you just put the country name on top of it. And that's it. And it's in the interest of the donors to low-income countries, because they would like to show off for the donor, and the governments [would like to say] "look what we have done in country X.""*

Imbedded in these dynamics, participants identified three main areas of improvement to revamp national action plans and better their implementation. The first is an emphasis on studying the ground

in which these plans are implemented, gathering the right evidence, and understanding the different political, economic, social, and cultural dynamics driving AMR in that context. Monetary funding should be relegated to a healthy second place:

"[We have to] understand the systems in the first place. Understand what can be driving the problem from the ground and why the solutions that you are providing from your mansion or whatever might not be realistic. And so the West, we all have a role. That role is not money all the time. Sometimes that role is taking the time to understand the complexities. Maybe some aspects of AMR cannot be addressed if you do not address poverty for example."

"One of the major issues in terms of how we implement a national action plan is also the policy narrative that does not usually match the picture on the ground, and I will say the global policy narrative, so to speak. Because most of the time, we are told from up here that this is the issue, and this is the global solution that we are providing for this and you adapt that global solution to your reality. And this will not work, it will not work, especially when on the ground, the picture is vastly different from the evidence that you people use in developing the policy framework that now must inform every country's solution."

The second point is the importance of involving local stakeholders in the process of NAP development and implementation, rather than dictating dos and do-nots. This is achieved by fostering trust and a sense of mutual contribution as well as garnering their enthusiasm and investment in the success of an action:

"I do believe it's very important that high income countries help develop low- and middle-income countries. But it's always very, very important that it's being run by the local governments. If a foreign institution comes in to establish something, [it has to be done] by the locals so that they see the need and are encouraged to [apply it]. We have seen numerous examples around the world where foreigners come into a country to fight an infection and epidemic and then the compliance is minimal simply because it seems like the action is not well intended or selfish."

The last one is the need for long term engagement between donors and countries to enact real change. One participant illustrates this point with the Norwegian experience working with Palestine:

"In order to make a change you need to have a long-term engagement between donors and countries and it's a lot to do with capacity and competency buildings. [For example,] Norway started slowly in 2008 to engage with [Palestine] to discuss whether they needed a Public Health Institute and I was seconded to them from 2012. So that's 10 years ago. And we still continue this collaboration

defining new ways. Like now we're discussing how we can improve health information systems and surveillance systems for communicable diseases including One Health AMR. So it's a long term, ongoing process that will take 10, 15, 20 years."

Despite the aforementioned dynamics, two participants commented on the rise of the global south. LMICs are moving beyond the language of the developed/developing dichotomy and taking the role of active actors in their development, in what can be a bid to reject high power distance on the global stage:

"I see that many African countries [now think:] we cannot just copy the European ways of doing it, we need to develop this for ourselves. Africa CDC is rather a newcomer on the scene but they are working to establish national public health institutes in all African countries to assist them in surveillance systems, in guidelines and so on. So it's something that I really like to see coming. It's in the face of decolonization, it was blaming the occupier, the colonial power. Now moving more to "okay, this is history. This is the past. We cannot just blame the aggressor from the past. We need to take action ourselves and we need to assist each other." And I see more of that now than I saw some 10 years ago."

d. Incentives for international collaboration

Participants argue that there is a strong case for high income countries to invest in global action against AMR. One expert demonstrated this point with evidence provided by the World Bank stating that high income countries are set to reap the highest returns on investment, exposing vested interests as stronger incentives to invest and collaborate than global public good:

"There is a strong economic case to be made [which] was already documented several years ago. The World Bank made a very strong case that this was one of the most cost-effective investments in development today. They proposed a 9$ billion package to support 130 countries in bolstering their public health and veterinary infrastructure to better address concerns of AMR. What they actually concluded was that although low and middle countries would have substantial economic benefit payoffs from such an investment, disproportionate returns on that investment would flow to the upper income countries: high income countries rather than upper middle-income countries. [Meaning] the countries are best positioned to pay for this package would also feed the greatest benefits from it. So although there is remarkable global public good value to it, there's also significant, frankly, self-interest value for these countries to invest."

The report the expert alluded to was dated March 2017. I could not help but wonder why engagement in such a package was slow to be garnered, which the expert suggested could be due to political dynamics and the difficulty of generating interest in preventive action to issues seemingly situated far off in the political future:

"A lot of it has to do with how policy issues receive priority in the global health space. Oftentimes, you need to put a human picture behind it to motivate policymakers, or they need to see new returns in order to make those kinds of investments. [Then] one begins to think about approaches that may not have returns for years, or worse yet have prevention benefits [that are] oftentimes not visible and a little hard to quantify and make you get up in the morning to actually vote for significant resources towards."

e. Obstacles to data sharing

Participants identified four challenges facing AMR data reporting and sharing. The first is a lengthy process to define and agree on reporting norms and standards:

"Collaboration on AMR surveillance in the EU system with ECDC has been a long, long process to agree on the protocols and what to report and what not to report… So this is a quite large normative process that you will need to go through."

One participant illustrated this point with Norway's incomplete data sharing on GLASS, which they attribute to the unavailability of certain data on The Norwegian Surveillance System for Antimicrobial Drug Resistance (NORM):

"We cannot report according to GLASS protocol on urinary tract infections because they only asked for the [severity of the infection] or they need the clinical component to it. NORM doesn't have that, they only have this bacteria has been isolated from urine, but they don't have clinical information about severity or what kind of infection this is and then it's difficult to report. so I know this has been an issue with Norway and the WHO regarding the GLASS protocol."

The second point identified by participants is the "information is power" mentality. Attitudes dictated by that adage hinder sharing of AMR data as well:

"That's also an attitude thing. I remember when I started working at the Public Health Institute in Norway, we gave out weekly bulletins, and it was stated on the front that you're not allowed to copy these figures without prior acceptance from the institute. And you see that in many countries that information is power. We have seen this in Palestine during COVID [wherein] those who do the COVID

surveillance would like to do all the analysis, they would like to decide what they would like to share because it's power. What we need to change in the attitudes and the mentality is that this should be shared."

The third point is a sense of national pride that can induce a reluctance to share complete and accurate data from officials. Added to that are the politics of blame and blame avoidance. One participant elaborates:

"Blame. Infectious diseases, it's all about blaming each other. And every country would like to look good and if you have polling figures on AMR, you don't want to look bad for other countries. So it's pride. And same with vaccination rates. If you have really appalling vaccination rates in your country, you feel embarrassed and [...] you would like to make the figures look nicer. So whether you don't publish it or you try to publish it in a way that makes you look good, countries will always try to do that."

The final challenge is a simple question: "Why report data at all?". One participant argued that the rationale behind data sharing lacks clarity and the motivations provided to the extra labor it costs unsatisfactory:

"I also think that the real question you should ask is not whether particular countries actually have submitted or not, [but what is] the rationale [and motivation] to share the data? Because it's all voluntary, it takes extra work. And if it's already been collected, as you're suggesting in the United States, then obviously someone thought it wasn't even worth the time to do it, because it's probably publicly available. So it's not a matter of hiding. It's just a matter of well, why should we be bothered if you're not going to do anything [with it]?"

They added that GLASS should do a use case to justify data sharing and showcase how it impacts policy both in the global and local settings. The burden of proof then does not lie with the participating countries, but with the organizing institutions:

"But I would have to say that the GLASS observatory has to make the use case to countries as well. And that is very important to establish [...] transparency: how are the data being used effectively to inform or motivate policy change? Otherwise, it is very difficult to encourage a ministry that has not shared such data to become motivated to do so. They have lots of work to do, and limited time. So if you're going to actually ask them to go out and collect the data, which may not even be collected these days, you have to do a use case as to how that data is going to be helpful to them."

3. The metrics and determinants of AMR

a. The narrative of AMU consumption

One participant argued that the current trend among academics and policymakers to consider antimicrobial consumption as the main driver of AMR is not only a false narrative, but also a harmful one. Not only is the balance tipped in favor of HICs who are the bigger consumers of antimicrobials, but that narrative covers up for the role of other, more upstream drivers of AMR. They explain:

> *"The problem with that narrative [is that it's,] first of all, not true. Access to antibiotics [...] in low and middle-income countries can be deeply problematic and people who don't have access to those drugs will suffer. So access versus excess. I would say excess is probably more of a problem in high income countries. But the concept even of access versus excess, and the concept of the problem lying with the individual who's consuming the antibiotic or the prescriber of the antibiotic, for me, is such a downstream abnegation of responsibility for the larger systemic problems that drive people to prescribe or need antibiotics in the first place. So that narrative is an easier narrative to understand. And so I understand why people use it or they adhere to it or they default to it. But a narrative is a story. And a narrative is not the truth."*

b. An alternative narrative

They added that work on the AMR should start with reframing it within the broader public health narrative, wherein it is incorporated in a horizontal approach that tackles it along with other Sustainable Development Goals (SDGs):

> *"I think reframing the concept and the problem of AMR might be a useful place to start. So I often say, sure AMR [...] might be a complex problem, but what does that actually mean? Where can you reduce AMR but also have co-reductions in other areas of public health. Because AMR is a public health problem and a social justice problem at its core. Siloing it off as this exceptional area that's terribly complex and needs specific funding streams that might have worked in the last decade but [wouldn't] in the period following the COVID pandemic I don't think is the smartest way of conceptualizing the problem. [...] Figuring out where AMR aligns with other SDGs might not be an easy win, but it might be a particular gain, as we move forward into, what I expect, will be a very resource constrained but public health aware decade."*

This opinion was echoed by other participants who stressed the importance of engaging work on the social and economic determinants of health to effectively address AMR. One participant expressed:

"So you have some social determinants [like education and unemployment] that are very, very critical, that need to be looked at if we are going to want to talk about effectively addressing this. This is why even in places where we keep dumping money all of the time, the solution sometimes is not there, because what we are doing is simply putting a bandage, meanwhile, the real issue is underneath and it's getting worse."

Another emphasized the need to reduce poverty and health inequalities:

"You can reduce a lot [of infection] by reducing poverty but still you will need antibiotics. And in many countries, lack of antibiotics available for treating infections is killing more people than AMR still, so but of course to reduce poverty and reduce inequalities in health is always important."

And another illustrated this point by the gains that could be obtained on viral meningitis outbreaks in Palestine if clean drinking water were widely available and accessible:

"... like for Palestine again and especially for Gaza, clean water, access to clean water, is extremely important and 95% of available water in Gaza is unfit for human consumption. Because it's too saline and full of nitrates and so on. Then you could reduce these outbreaks of viral meningitis for example, because it's mainly the Coxsackie virus and so on."

DISCUSSION:

This study assessed 60 national action plans on AMR from the six WHO regions with a focus on surveillance, reporting and international collaboration. These documents are the offspring of political momentum for internationally coordinated AMR policies in the 2010s which culminated with the Global Action Plan on AMR in 2015 under the guidance of the WHO [34, 114]. In our study, and out of the 60 documents, only five were drafted prior to the GAP. Indeed, the latter served as a starter, blowing the first whistle to commence the race; the objective being: local action plans that are aligned with the five guiding strategic objectives of the GAP [34]. According to the Tripartite AMR country self- assessment survey which was designed as an implementation progress monitoring tool [115], 130 countries have developed local NAPs as of 2020 [3].

Focusing on the aforementioned topics, I set out to evaluate the implementation of these NAPs following a simple logic: proper implementation of surveillance, reporting and collaboration objectives would lead to the production of data. Therefore, and due to the comparative nature of this study, I excluded all countries who had not joined GLASS by 2019 as the latest available AMR data were from the same year at the conception of this study. This left me with 82 countries. Yet, despite the droves of numbers, I could only locate 69 of these documents online on public repositories. Over one third came from Europe and four out of ten from HICs, which points to the importance of two components in the development and implementation of NAPs: Financing, and regional frameworks and collaborative bodies. A 2017 paper by Essack et al. looked into the status of AMR in the WHO Afro region and came to a similar conclusion: that while developing and implementing plans is incumbent upon local governments, bodies such as WHO-Afro are responsible for leading the way and assisting countries as they are in different stages of preparedness to address AMR [116].

A. Alignment and implementation

When it comes to AMR surveillance, national action plans served one of two purposes: either a first guiding effort to develop surveillance systems of both AMR and AMU, which applied to all low- and lower-middles income countries, or an opportunity to mend the shortcomings of pre-existing surveillance systems of countries with higher income; challenges that included: poor integration of data, partial data collection, lacking information technology infrastructures, as well as poor policy design.

NAPs human surveillance objectives were well aligned with the GAP. All countries committed to developing national AMR and AMU surveillance mechanisms, and most (47/60) to include collection of data on HAI causing organisms. The scope of this study did not extend to review reduction goals. There is; however, some literature that does. A 2021 analysis of NAPs in South-East Asia by Chua et al. showed that only four out of the ten included countries had established reduction targets of AMR, AMU or HAIs [38]. An older 2017 survey showed that out of the 32 Transatlantic Taskforce on Antimicrobial Resistance (TATFAR) partner countries, only nine indicated having established targets of AMU reduction in humans, and 17 responded that such a work was underway [117].

All countries committed to improving their laboratory capacity. However, HICs were mostly concerned with developing and implementing cutting-edge technological solutions, while countries of lower income were focused on building basic surveillance capacity. With the exception of investment in early detection and warning systems, the LMICs NAPs were well aligned with the GAP objectives that included strengthening laboratory networks, standardizing testing and reporting, creating reference laboratory centers, and quality assurance. Notably, there were a few exceptions to this income-driven pattern wherein some HICs like Saudi Arabia and Croatia followed the same structure and focus observed in LMICs laboratory strategy. I can thus infer that a country's previous experience with surveillance is more impactful than income in developing future action.

All the NAPs that postdate the GAP took the One Health pledge: to obtain optimal health for people, domestic animals, wildlife, plants, and the environment, as well as integrate their surveillance via the collection of relevant microbiological and epidemiological data on AMR and AMU. However, despite these aspirations, concrete action alignment falls short. Surveillance was mostly focused on human health, followed by animal health. Only about half commit to any kind of action on the environment or agriculture, with little indication of intersectoral collaboration. This result is consistent with Munkholm et al.'s 2021 analysis which suggests that the environmental sector receives less attention than human and animal health in AMR NAPs [118]. Indeed, a 2021 evaluation of the Tanzanian NAP by Frumence et al. revealed that one of the shortcomings of its One Health engagement was the dominance of the health sector stakeholders and the non-involvement of the environmental sector, added to that was the siloing of action and accountability is all sectors [119]. Additionally, and despite countries' commitment to monitor AMR and AMU in animals,

implementation is not well evidenced. A 2020 evaluation of the Bangladesh NAP revealed missing evidence to support optimal use and surveillance of antimicrobials [120].

All the countries aligned with the GAP's objective of AMR and AMU reporting in human health. Nonetheless, while the commitment was explicit, concrete reporting frequency was not determined in one out of three documents, and twelve countries did not commit to sharing data at the time of the NAPs conception. All the countries included in this study have since joined GLASS, so it is safe to surmise that this objective has been revisited and improved. Most countries also aligned with the GAP's cooperation objectives by engaging in regional and international collaboration efforts and networks.

This alignment; however, does not translate into data. Around one third of included countries have not submitted any data to the 2020 GLASS call, half of them from WHO-AFRO. Our choice of proxies aligned with the WHO's recommended indicators to monitor and evaluate the GAP [121], as well as had the benefit of covering two of the most common infections in two different and widely tested samples. Nevertheless, data on both were only found in two thirds of countries with a submission record, and very few submitted complete AST data on all antimicrobials.

Additionally, the interpretation of the observed high resistance rates was hindered by the low antimicrobial susceptibility testing, as well as the subpar disclosure of numbers of infections and their origins; a pattern that concerned all regions and crossed income lines. I contrasted Norway's GLASS data submission to that of the 2020 NORM report, and while there were some discrepancies (4072 urinary *E. Coli* infections and 1501 *MRSA* infections on GLASS vs 2520 and 1720 on NORM, consecutively), they can be jotted down to possible variations in sampling periods: in 2020, NORM Urine *E. Coli* samples were collected over a one-week period, and S. aureus over a 9-month period [122]. The origin of infection however was not specified on the NORM report as it simply states: "NORM is based on a combination of periodic sampling and testing in primary diagnostic laboratories, and annual results from national reference laboratories for specific microorganisms". This concords with an interviewee answer that attributed Norway's incomplete data sharing to a straightforward unavailability of certain data (Page 84). Such is also the case of Tanzania, where a 2021 evaluation of the country's NAP indicated: "The 2020 GLASS reports show that Tanzania did not submit data on any priority pathogens in 2019 because the country had recently begun

surveillance, with the participation of a few laboratories" [123]. The lack of data in the African region is a direct result of poor surveillance systems [124]. An evaluation of the Ghanian NAP published in April this year by Hein et al. indicated that despite receiving two Fleming Fund grants, Ghana has not managed to contribute data to GLASS due to persistent problems with infrastructure [125].

Participants have identified additional challenges to reporting related to old competing mentalities and fear of accountability. The latter is best illustrated by contrasting GLASS country participation to that of the OIE annual reports on AMU in animals. While GLASS opts for transparency by identifying participating countries and their data, the OIE limits its disclosure to regions, not identifying the sources of submissions. In 2019, the fifth round of OIE data collection boasted 156 reports [126], against 66 AMR reports in the 2019 GLASS data call [40]. And while the comparison may not be fair considering GLASS is a newcomer and AMR rates are harder to track, it does pose the question of accountability vs hesitancy in a system that relies on voluntary surveys and reports.

While most documents aligned with GAP objectives within the scope of this study, there were strong variations in structure and content between countries and regions that follow along income line[125]s. Structurally, while documents of LMICs tended to be generic adaptions of the GAP and at times blatant copies pastes of each other (as was the case of India and Afghanistan), documents from HICs were more likely to be individualized, for lack of better term, and to showcase limited overlap with the GAP structure. Contentually, the language of NAPs from LMICs tended to rely on nomination and passive structures where actions donned no actors:

"Unifying national laboratories standards and guidelines …" [73]
"Standardization of Antimicrobial Laboratory testing and unifying the MDROs definitions" [77]
"Establishment of an integrated national AMR surveillance system" [72]
"monitoring and supervision of drug dispensers to encourage compliance.." [59]
"There shall be established national monitoring systems for antimicrobial …" [54]

These observations are corroborated by a 2020 study by Munkholm and Rubin which looked into NAPs alignment with the GAP using a syntactic indicator measuring the degree of verbatim overlap between the two [119]. Their analysis shows stronger vertical syntactic overlap in developing countries compared with developed countries: the poorer the country, the more verbatim similar the NAP is to the GAP, suggesting the presence of income and geography patterns. The study also looked

into horizontal alignment between NAPs and revealed inter- and intra-regional patterns of syntactic overlap wherein the WHO South-East Asian region donned the highest level, and notably, more than 50% of Afghanistan's NAP was verbatim to India's NAP, while 66% of India's is similar to Afghanistan's [119]. The researchers also used a second content indicator born out of the systematic content analysis of NAPs to determine their alignment with the GAP. Similarly to the syntactic analysis, high income had a negative effect on alignment: the poorer the country, the more it shared content with the GAP. High degree of vertical alignment, nonetheless, was not found to correlate with high implementation following an additional analysis of reported implementation measures in the Tripartite AMR Country Self-assessment Survey. The researchers describe the phenomenon as "isomorphic mimicry", or "harmonization that takes place primarily in form and not in function". They go on to explain the mimicry behavior by the urgency and the scope by which these NAPs were developed, wherein a great number of lower income countries with other challenges had a short timeframe to achieve that. This may lead to the promise of actions countries possessed no capacity to carry out, somethings the writers refer to as "capability traps" [119].

Poor NAPs implementation was further evidenced by a 2021 analysis of NAPs in the WHO-Afro region by Iwu et al. [127]. The authors used 53 indicators to create and evaluate an implementation performance score per country: The average overall performance score was of 32%, better than the average surveillance performance score which was a mere 18% [127]. The numbers illustrate a "doing gap" diagnosed by the World Bank, wherein the level of details in a NAP is no measure of its success [128].

B. Implementation challenges

Expert interviews identified many challenges facing the implementation of the NAPs on AMR. Despite countries committing to a One Health framework, AMR action is crippled by poor integration of the approach, but also political, economic, behavioral, socio-cultural, and regulatory dynamics, among others. This study highlights how arduous it can be to address AMR in the absence of a comprehensive approach that takes into account its many drivers and determinants. Unless an effort is made to understand how these elements interact and move AMR, it will not be possible to design good policy, and NAPs are bound to remain boilerplates with little impact on surveillance. I attempt to discuss each of these dynamics in the following paragraphs.

First, it is important to acknowledge the role of political buy-in and policy environment in the nascence and execution of NAPs. The WHO describes health as a political choice where health priorities are decided by governments and political penchants [129]. Political will is therefore paramount to prioritize, design and implement sustainable action on AMR as it requires strong governance structures and the coordinated effort of multidisciplinary and multisectoral actors [130]. A 2019 study by Ribeiro et al. identified systemic fragmentation as a root cause for coordination challenges, wherein organizational silos segregate the various sectors and institutions involved in AMR and AMU monitoring [131]. Power dynamics between policy makers and stakeholder are also important to consider as they determine the local policy context and give rise to conflicts of interests. In their 2020 study on NAPs implementation barriers in LMICs, Khan et al. described vested interested connecting policymakers with pharmaceutical and livestock industries which eventually result in a reluctance to support strong regulatory approaches [132].

Second, a sustainable action plan requires robust funding. However, current available financial support for NAPs implementation is inadequate, particularly in LMICs [133]. For many, AMR reduction is not considered a financing priority as its benefits are not regarded as tangible: Only one in five countries responding to the 2019 TrACSS reported having identified funding resources for their NAPs [3]. The sustainability of NAPs is further hindered by reliance on donors and development partners to secure funding. For example: the Fleming Fund, a UK aid program to support AMR surveillance, had given grants to 27 countries, 15 of which are included in this study [134]. This is particularly critical as countries move up in the ranks of economic development and may no longer qualify for extensive support packages. This is the case of Bangladesh where a 2020 paper by Orubu et al. indicated that the country's reliance on partners like Fleming Fund, USAID, and Global Antibiotic Resistance Partnership poses a serious challenge for the sustainability of its policy implementation [120]. The sentiment was echoed in Frumence et al.'s evaluation of Tanzania's NAP [123]. The World Bank has, nonetheless, made a strong economic case for AMR in its 2017 report, describing substantial economics payoffs with the highest yields flowing to upper middle income and high income countries [7]. Yet, despite the many partnerships, global financial support to LMICs on AMR remains inadequate: the Tripartite Multi-Partner Trust Fund on AMR has mobilized less than $15 million in support, a number described as "barely a rounding error in what has been spent on COVID-19" by the Antibiotic Resistance Coalition [135].

Nevertheless, there are calls to leverage existing resources and established funding streams to strengthen AMR activities instead of building vertical programs [136]. AMR-sensitive programs like WASH, immunization, nutrition, education, and communication present opportunities to mitigate AMR without further financial burden in resource constrained settings [137], a notion echoed by participants' responses. A 2020 paper by Maillard et al. makes the case for the contribution of basic targeted hygiene practices, clean water, and adequate sanitation in AMR reduction through infection prevention and the reduction of antimicrobial prescribing [138]. This was found to be relevant for all countries regardless of the overall social and economic development, but is particularly pertinent in LMICs as there are more infection risk factors (poor sanitation, lack of environmental regulations, high-density housing, and inadequate access to clean water) [138].

Third, successful control of AMR requires the participation and buy-in of the workforce, the public and the community, both to draft and implement actions. Healthcare professionals' involvement is critical to AMR reduction, from regulators to community pharmacists who are the first point of contact with the public. It starts with understanding the motivations and vested interests of these stakeholders. A 2019 exploration of the AMR policy in Singapore by Singh et al. indicated that prescription practices can be influenced by vested interests such as the promise of additional income, as well as patient pressure to receive antibiotics even when not necessary [139]. On the other hand, they have described a tight knit connection between policymakers and academics which results in the translation of research into health practices, as well as increased motivation among the workforce [139]. Successful AMR reduction is contingent on professional's trust in governing bodies, but also on the public's trust in public institutions. The latter is achieved by involving community as a stakeholder both in infection prevention and antimicrobial consumption. Despite acknowledgment of its role, studies show that on the ground application is still lacking: A 2018 systematic review of several European countries indicated that citizens' engagement was poor, as they were expected to be recipients of awareness or education interventions rather than actively engage in pro-active preventive measures that would reduce their need for antibiotics [140]. Similarly, evaluation of the Tanzanian NAP revealed that community members were only included in the implementation stages of the plan, and were left out of the design and preparation stages [123]. Ghana; however, is regarded as a success story for using civil society organizations to bring AMR and AMU education and awareness to the community, especially within farmer groups and associations [141]. The current

AMR rhetoric assumes that knowledge and awareness of the problem will lead to good practices. It fails to consider; however, the impact of social, cultural and human drivers that determine behavior [142].

Stakeholders buy-in is also critical to support AMR regulation as the latter may be resisted and contested if perceived as a threat to their vested interests [143]. The difficulty with AMR regulation is less to do with lack of legislation and more to do with its inadequacy and poor enforcement. Porter et al. describe patchy or non-existent enforcement in LMICs that is the result of a traditional top-down model of regulation [143]. The latter is conducive to laws written in disregard of situated interests and "how socioeconomic and structural factors underpin behavior" [143].

Fourth, it is important to consider the role of policy discourse in defining the global and local approach to AMR. Wernli et al. identified five ways AMR is framed in global policy discourse: AMR as healthcare, AMR as development, AMR as innovation, AMR as security, and AMR as One Health [144]. Curative treatment of AMR requires a shift of perspective away from the reductive innovation- and healthcare-based approaches to a holistic development perspective. AMR is compounded by and also contributes to the various drivers of health, hence the increasing need to address the various social, economic, cultural, and political drivers at play rather than focusing on treatment and technical solutions. There is some research to support this: an investigation on health inequalities and infection disease in Europe revealed a social gradient wherein structural and social factors such as crowding, homelessness, income, education and occupation put some groups in higher risk of infection and thus an increased burden of disease [145]. A review of AMR drivers in India indicated that, among other contributors, poor sanitation, environmental pollution, and poor public health infrastructure have created hospitable conditions for the rise of multi-drug resistant organisms [146]. A 2021 paper by Othieno et al. elaborates on the role of poverty in disease spread: poverty has an effect on the way messages are received and decoded by the audience, resulting in resistance promoting behaviors [147]. Medication scarcity leads to inadequate and unjustified prescriptions by professionals, as well as promotes risky behavior in patients like sharing or saving medication for the future [147]. Despite available evidence, AMR is still regarded as an innovation issue that manifests in a focus on developing new substances, diagnostics, and downstream technical solutions. Viewing AMR as a development problem creates the right space to find solutions as much of health is decided

outside of healthcare [148]. Efforts in this direction have materialized in 2021 with a Tripartite report that redefined the relationship between AMR and other SDGs and added two indicators as part of SDG 3 (good health and wellbeing): Percentage of bloodstream infections due to selected antimicrobial-resistant organisms and proportion of health facilities that have a core set of relevant essential medicines available and affordable on a sustainable basis [149]. The authors of the report call for including AMR in the UN Sustainable Development Cooperation Framework which identifies the country's development priorities and defines the UN's contribution to them, and would help underscore the urgency of reducing AMR by linking it to broader development issues [149].

fifth, continuous monitoring and evaluation of any plan is an important component in the implementation process. Such an evaluation is contingent on access to data that is then transformed into actionable knowledge. AMR data, whilst gaining ground in terms of collection, is still monopolized by international repositories and remains mostly unavailable to local stakeholders. NAP evaluations in Tanzania and Thailand note that stakeholders have difficulties accessing this information, despite the policy destining national-level data to inform decision-making [123, 130]. Data should be shared more actively with concerned stakeholders to promote its use in policy making [128].

And finally, war and aggression on sovereign nations contributes directly to AMR as well as hinders efforts to reduce it. On the one hand, war disrupts and weakens health systems in afflicted countries, and diverts resources from efforts of infection control and AMR surveillance to enhancing defensive capabilities and more urgent care. On the other hand, a WHO report identifies two major social determinants in conflict settings [150]: The first is loss of human rights that translates to displacement, loss of employment, food insecurity, lack of water and sanitation as well as isolation of entire communities. The second is the breach of medical neutrality which manifests in damages to infrastructure, attacks on health facilities, providers, patients, medical convoys and ambulances, as well as barriers and checkpoints obstructing access to care. All of this enables a ripe environment for infection and resistance to fester, and therefore translates directly into an increased AMR burden. A 2019 article by the ReAct group indicates that resistance has been reported in virtually all recent conflicts, especially in Iraq, Syria, Yemen, Afghanistan and Palestine [151]. The numbers are worrisome: According to Médecins Sans Frontières, 70% of infections were multidrug-resistant in

2018 in their Trauma Centre in Aden, Yemen [152], and 90% of infections in a post-operative care facility in East Mosul in Iraq were multi-drug resistant between April and mid-November 2018 [153].

C. The AMR narrative, power dynamics and the way forward

The present AMR approach is a direct result of the language used to communicate its risk. The latter is described using a minimalist trifocal framework that centers around: 1) the what, 2) the object, and 3) the consequence [154], which goes something along these lines: Microorganisms' resistance to antimicrobials affects society and results in death, loss of labor, and loss of income, all capitalist terms that are most likely to be encountered in a World Bank report. Dr Fage-Butler, an expert in Knowledge Communication, argues for the need to broaden the definition of Risk to not only include who or what is responsible for it, but why, and who's responsible for averting it, why and how, and to consider other intersecting layers [154]. In the case of AMR, that amounts to going beyond the biology to understanding its underpinnings and redefining our solutions.

The dominant discourse around AMR is that of imminent risk and fear, or what Mendelson et al. refer to as the "war rhetoric" [155]. "tackle", "fight", "combat", "superbugs", and other martial terms are commonly used to discuss AMR in academia and policy [156]. The language is apocalyptic and is further aided by alarming reports such as the 2016 O'Neil report that paint the problem in urgent colors. (Whether the numbers are accurate and the data speculative or well evidenced remains debatable). Such discourse traps AMR in a global health security approach which, in theory, aims to protect people's health across geographical regions and international boundaries [157], but in practice tends to the concerns of the global North vis-à-vis the international spread of diseases emerging in the global South [144]. The result is interventions that are centered around improving AMR surveillance as a condition for containment of AMR at its perceived "source" [144]. This global blame narrative needs metrics to justify it. Enter antimicrobial consumption, a driver discussed as the biggest and main driver of AMR while disregarding the problems of excess vs access, and overlooking the nuance between gross consumption and consumption rates. A 2022 comparative assessment of NAPs from OECD and G20 countries by Özçelik et al. shows that mentions of terms associated with optimizing antimicrobial use in human and animal health were highest, while terms linked to raising AMR awareness and education were at the back of the pack [158].

This narrative oversees the agendas of international collaboration with an observable gap between globally determined aims and national realities. Funding and cooperation efforts are focused on downstream interventions and do little to respond to countries' development needs. NAPs need to be locally focused, to engage local stakeholders, and data they produce must be actionable, which can only occur if the global North relinquished its control over policy [114], or at least made space for LMICs to determine their priorities. Following the migration of antibiotic manufacturing from Northern to Southern countries, and growth markets from Western countries to LMICs, the global North was barricaded inside policy and took on the self-designed roles of antibiotics steward and industry regulator [114]. Therefore, calls for locally focused but internationally funded NAPs may further impact the participation of HICs in global initiatives in the absence of appropriate incentives. There are proponents for a law-based approach in the form of globally binding international treaties to further concerted effort on AMR [38, 119]. However, we have to wonder about their chances to see the light considering their dependance on rich countries to initiate action, their added burden to resources, as well as their heavy reliance on political will [16]. And if action on Global Warming has proven anything, it's that political will is fickle, has a short attention span, and is herded by perceived national self-interests. One solution may be to put a face on AMR, the same way the world has assigned emaciated African kids to hunger and masked faces to Covid19. The task would; nonetheless, be more difficult due to the silent and invisible nature of AMR and considering it cannot be divorced from other healthcare and development issues.

It could be argued that this study has fallen in the same trap of global health security discourse by focusing on AMR surveillance as a main indicator of NAPs success. But I would argue that I was attuned to the nuance from the beginning. This study would be best characterized as a journey of awareness, wherein I started with available literature, applied critical thinking, then explored other venues of understanding and listened to other opinions. The possible contrast between my language in the literature review and my language here is a reflection of that growth, and in my understanding, a pure application of grounded theory.

D. Limitations

This study has a few limitations. The sample size was determined by the availability of data on the GLASS which led to a disproportionate regional distribution. I could not thus perform a regional analysis or comparison between the various WHO regions. The sample size was; nonetheless, robust with a good distribution across income, which allows the generalization of observed patterns and results. On the other hand, the objective analysis of NAPs may have missed some measures as it was done manually and by one person, although this was minimized by several run-throughs and verifications during various stages. This study could benefit from reviewing a larger body of documents that could include operational plans in addition to national action plans, and extend to cover more proxies and data from more recent data calls. It would also be useful to do individual case studies that contrast each NAP to its corresponding GLASS data, and eventually a regional analysis if sampling allows. Other useful input can be derived from a Corpus analysis that would facilitate a linguistic approach to NAPs. Currently, Oslo University is involved in building the Oslo Medical Corpus that will include, among other documents, all NAPs on AMR [159].

I was not successful in acquiring my target number of participants. I planned to interview at least 15 from various affiliations, which would have provided a better exploration of NAP implementation challenges and helped reach data saturation. It did not happen due to poor response rate. Nevertheless, the interviewees had relevant experience with NAPs and their implementation, so the gathered results had decent explanatory power. A larger sample of experts from various WHO regions and with local stakeholders would be more informative.

CONCLUSION

In this study I analyzed 60 national action plans and looked into their alignment with the GAP surveillance, reporting and international collaboration objectives, as well as how well they translated into AMR data on the GLASS portal. An additional objective was to investigate challenges to their implementation via semi-structured interviews with experts. I set out to answer what I deemed was a simply formulated question: Are National Action Plans effective in producing and reporting surveillance data? The answer is nonbinary. The results show that most countries are not sharing quality data on WHO's Global Antimicrobial Surveillance System, a trend that crosses income and geographical lines. This is, in part, due to poor surveillance systems and a lack of data, following which the answer to my question would be that NAPs are not effective in producing quality data either. However, we have identified additional challenges to reporting. One of which is that WHO's data requirements do not always align with countries' systems, resulting in incomplete data sets even from countries with reputable AMR surveillance. The other main challenge is poor impetus and hesitancy to volunteer labor-intensive data, as it is possible that data is shared on other systems or is simply not made public. It is, therefore, essential that WHO makes a use-case to countries to galvanize AMR data reporting all while promoting accountability.

It is safe to surmise based on evidence from this study that NAP implementation of AMR surveillance mechanisms is lacking. Furthermore, good alignment with GAP objectives and commitment to surveillance does not guarantee data production or sharing, independently of income. However and while it is informative, relying exclusively on surveillance metrics to inform on the success of a NAP would be partisan as it serves the agenda of the global health security discourse at the expense of approaching AMR as a development issue. The problem of AMR is the sum of the many drivers and determinants that create a hospitable environment for its spread. Overlooking these is the root of a tree whose branches bear consequential fruits of various dynamics: political, financial, regulatory, and socio-cultural. All of which constitute serious challenges to countries seeking to implement new AMR policies.

Studies that focus on NAPs evaluation are topical and essential in a time that sees a multitude of these documents sprouting around the world. This study adds to the growing yet limited literature on the topic and stands out by its triangulation of quantitative and qualitative data. For further

research, I recommend expanding the scope of document selection as well as to include more interviews from various WHO regions and local stakeholders.

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APPENDIX A: Interview guide

Introduction:

- Brief introduction about the topic,
- Explain what the interview will be used for,
- Ensure confidentiality and verify the desire for anonymity,
- Ask if participant has any questions or desires further explanation,
- Obtain verbal consent to record,

On AMR:

- On what sparked the interest in the topic,
- The interviewee's perspective on AMR and extent of the problem,
- On the place of surveillance in AMR strategies,

On NAPs on AMR:

- Experience working on and researching NAPs,
- How different countries are faring
- Policy development vs implementation?
- Key challenges facing implementation
- Differences between east/west? LMICs vs HICs?

On international collaboration and reporting:

- The place of international collaboration in AMR reduction
- Ways to incentivize action
- Issues facing data reporting
- On the AMR narrative and metrics

Potential solutions

- How may implementation be improved?
- Should the entire approach to NAPs be overhauled?

Conclusion:

- Anything to add?
- Any questions?

APPENDIX B: NAPs summary

Country	Document Language	Start year	End year	Purpose of policy	Stakeholders involved	Surveillance	International cooperation	Reporting
Afghanistan	English	2017	2021	To combat and reduce the impact of AMR in Afghanistan. Reflecting the five principles of GAP	Ministry of Public Health Ministry of Agriculture Irrigation and Livestock National Environment Protection Authority Ministry of Information and Culture Ministry of Finance Ministry of Higher Education Ministry of Trade National Center for Disease Control WHO Professionals in clinical health, microbiology, pharmacology, PH, animal health Social workers and activists Academic institutions	. National laboratory capacity to be strengthened . National reference laboratories to be identified and strengthened . To enroll in GLASS . National strategy for strengthen microbiology for AST testing to be developed, both in human, animal, and environment health . Training workshops for bacterial identification, antimicrobial susceptibility testing (AST) and data harmonization to be organized . National surveillance standards to be established . National modalities for data collections, collection and analysis and information management to be established . AMR surveillance database to be made available in all sectors . Antibiotics residue in food and environment to be tracked and monitored . National surveillance system of ATB use to be established	. Ministry of Health collaborating with WHO to review approaches and initiatives for combating AMR	. Annual report of national AMR surveillance with data from all sectors to be published
Argentina	Spanish	2015	?	To control AMR by three core actions: Promotion of rational antimicrobials use, Strengthening surveillance, and promotion of innovation in	Ministry of Health Ministry of Agriculture, Livestock and Fisheries National Universities of La Plata and of the Center of the Province of Buenos Aires. Representation for	. Pre-existing AMR surveillance mechanisms in healthcare, . To strengthen the network of laboratories participating in AMR surveillance, . To harmonize AMR surveillance strategies in humans, animals, and environment, . To develop an AMR surveillance	. AMR data shared with international bodies: the Pan American Health Organization and WHO, . To participate in international research	. Annual report on AMR surveillance data, . To produce annual reports on AMU

				testing and antimicrobials	the Americas of the World Organization for Animal Health (OIE). Argentine Society of Infectious Diseases (SADI) and Argentine Society of Intensive Care (SATI)	system in food animals, . To design and implement a system for AMU monitoring in all sectors,	networks and scientific events,	
Australia	English	2015	2019	To minimize the development and spread of antimicrobial resistance and ensure the continued availability of effective antimicrobials.	The Australian Antimicrobial Resistance Prevention and Containment Steering Group, which is led by the Secretaries of the Australian Government Departments of Health and Agriculture and includes the Chief Medical Officer and Chief Veterinary Officer, will oversee implementation and report publicly on progress.	. Pre-existing AMR and AMU surveillance system (AGAR) . To develop a national integrated system of AMR and AMU surveillance in human, animal, and agriculture, . To develop lists of priority organisms and associated antimicrobials for national reporting, . To standardize testing methods in laboratories,	. Production of a report on integrated surveillance in animals and agriculture that aligns with OIE standards, with the purpose of general internationally comparable data, . Provides financial and technical assistance to WHO regional office to support LMICs to combat AMR, . To share surveillance data with WHO, . To align testing standards with international standards set by WHO FAO OIE to support international surveillance, . To continue support of WHO FAO OIE in GAP development and implementation, . To partner with	. To share surveillance data with WHO, . To participate in OIE global initiative to collect quantitative data on the use of antimicrobial agents in animals to establish a global database,

							regional countries to strengthen regulatory capacity for medicines quality and safety, . To establish research collaborations internationally and regionally,	
Austria	German	2014		To efficiently and sustainably reduce the development and spread of antimicrobial resistance in order to maintain the effectiveness of the antibiotics and, where possible, to promote the quality of the antimicrobial therapies.	The federal ministry of health National Reference Center for Nosocomial Infections and Antibiotic Resistance	. Pre-existing national surveillance systems of AMR and AMU in human health . Pre-existing nosocomial infection surveillance system, . To strengthen surveillance systems to record AMR, AMU, and HAIs according to best practice models.	. Participant in EARS-net and ESAC-net	. Annual report on AMR and AMU in human, veterinary and food sectors,
Bahrain	English	2016		To reduce the emergence and prevent the spread of drug-resistant organisms through 5 core strategies: Education, Surveillance and risk assessment, Research, Prevention and control of infection, and optimization of antimicrobial use.	Ministry of Health Ministry of Agriculture Ministry of Finance Ministry of Education WHO	. To set up a national AMR surveillance system with a national reference center that oversees data collection, aggregation and sharing, . To improve laboratory capacity through microbiology training, . To establish national reference laboratory for humans and animals, . To set up a platform for data collection sharing in hospitals and laboratories, . To monitor AMU in animals, . To improve and measure AMU in humans	. To collaborate with WHO on WHO-Net training . To disseminate data to GLASS	. To report data to GLASS, . To collect data on AMU in humans and animals, . To report data on HAI surveillance,
Bangladesh	English	2017	2022	To establish multi-sectoral approach for planning, coordination, and	Ministry of Health and Family Welfare Ministry of Fisheries and Livestock	. To strengthen laboratory capacity and establish standard testing guidelines and protocols, . To identify national reference	. Partner of Jaipur declaration on AMR 2011	. To generate reports on AMU in humans and animals,

				implementation of AMR containment, to ensure rational use of antimicrobials, promote and strengthen infection control and establish a surveillance system.	UN organizations (?) (headed by Director General of Health Service and Director, Disease Control, DGHS as member secretary. Representatives from Drug Administration, Livestock and Fisheries directorate, high officials of DGHS, leaders of professional bodies of different disciplines and executives of UN organizations have been included in this committee. Some eminent personalities from different sectors are also incorporated in this committee.)	laboratories in human and animal health, . To establish a web-based national surveillance system and laboratory network on AMR in humans, animals, fisheries, and the environment, . To establish an information dissemination system . To monitor AMU in health care, animals, and fisheries, . To test for AM residue in food, Ensure Rational Use of Antimicrobial agents (AMs) in Human health, Livestock, Fisheries sectors, and Environment (Antimicrobial Stewardship-AS)		
Bhutan	English	2018	2022	to operationalize and facilitate the effective implementation of policies and plans to combat AMR effectively through multi-sectoral and multidisciplinary collaboration under One Health approach.	Ministry of health Ministry of agriculture and forests Hospitals and Pharmacies WHO	. To strengthen and improve laboratory capacity through equipment, personnel training, testing standardization and EQA, . To test for AM residue in foods, . To institute a national AMR and AMU surveillance system in human and animal health	. Financial support from WHO to develop NAP, . Partner of Jaipur declaration on AMR, . To collaborate on AMR research with international partners, . To acquire memberships in global AMR networks,	. To generate annual AMR reports, . To generate annual AMU reports, . To general biannual PPS reports of HAI, . To generate NAP progress report
Brazil	Portuguese	2018	2022	To ensure that the capacity to treat and prevent infectious	Ministry of Health (MS), National Health	. To build an integrated national AMR and AMU surveillance system in healthcare and in animals,	. To deploy GLASS,	

				diseases is maintained with safe and effective medicines that are quality assured and used responsibly and affordably by all who need them.	Surveillance Agency (Anvisa), Ministry of Agriculture, Livestock and Supply (Mapa), Ministry of Cities (MCidades), Ministry of Education and Culture (MEC), Ministry of Science, Technology, Innovations and Communications (MCTIC), Ministry of Environment (MMA), National Health Foundation (Funasa), National Health Council (CNS) National Water Agency (ANA).	. To create a national laboratory network for AMR monitoring, . To improve the national HAIs surveillance system,		
Cambodia	English	2015	2017	To develop and implement effective strategies to curtail the emergence and spread of AMR	Ministry of Health Ministry of Agriculture, Forestry and Fisheries professional associations international organizations NGOs academic and research institutions health care professionals. organizations: AMR Working Group World Health Organization	. To strengthen laboratory capacity, adopt standard testing protocols, establish an External Quality Assurance program, . To set up national reference centers, . To establish AMR surveillance in food-producing animals, . To set up capacity for screening of AM residue in foods, . To establish a national integrated AMR and AMU monitoring system in humans, animals, and foods, . To monitor rational use of AMU is the public and private sectors and well as sales and dispensing in pharmacies,	. Technical support provided by WHO to develop NAP . To participate in regional and international AMR networks,	. To produce annual AMR reports, . To produce AMU use and sale reports, . To produce annual reports on IPC

						. To regulate AMU in animals and monitor for AM residue in foods,		
Canada	English	2017		To establish a coherent approach to guide collective efforts in addressing AMR and AMU in Canada with a focus on four key components: surveillance, infection prevention and control, stewardship, and research and innovation.	Federal, provincial, and territorial (F/P/T) governments, Academic Non-governmental organizations Industry experts The National Farmed Animal Health and Welfare Council, The Canadian Veterinary Medical Association The Association of Medical Microbiology and Infectious Disease Canada Other health sector non-governmental organizations	. Pre-existing AMR and AMU surveillance systems in human and animal h at different levels of gov, not integrated, . To work on integrating and standardizing AMR and AMU surveillance in human and animals, . To create platform for data sharing	. Partner of the Joint Programming Initiative on AMR, . To support and improve research collaboration on AMR	
Croatia	Croatian	2017	2021	to improve and protect the health of the Croatian population by ensuring quality health care while preserving the effectiveness of antibiotics.	Ministry of Health, Ministry of Agriculture, Ministry of Science and Education professional and scientific institutions in the field of human medicine, veterinary medicine, economy and science and education	. To nationally monitor AMR in healthcare and veterinary medicine, . To nationally monitor AMU in healthcare and in animals, . To strengthen the laboratory network and implement external quality assurance,	. To participate in ESAC-Net and EARS-Net, . To share AMR and AMU data with other countries, . To maintain good international cooperation with institutions ECDC, WHO and OIE on the topic of AMR., . To participate in research on development of new antimicrobial drugs and technologies,	. To report AMR and AMU data annually,

Cyprus	Greek	2012		Development and implementation of actions that will result in reduction of the observed antimicrobial resistance to antibiotics in Cyprus.	Ministry of Health Ministry of Agriculture, Natural Resources and Environment Ministry of Education Medical, pharmaceutical, veterinary associations Healthcare societies Media	. National AMR surveillance database since 2012, . To continue monitoring AMR and AMU in healthcare and sharing data with ESAC and EARS, . To establish a National Antibiotic Consumption Inventory System in Livestock and Veterinary Medicine. And participate in the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC), . To continue surveillance of HAIs,	. Member of EARS-Net and ESAC-Net,	. To continue collecting and reporting on AMR and AMU in healthcare and sharing data with European networks, . To produce triennial progress reports on NAP actions,
Czech Republic (the)	English	2011		to ensure a long-term available, effective, safe, and cost-effective antibiotic treatment for patients with infectious diseases.	Ministry of Health Ministry of Agriculture Ministry of Education Youth and Sports Ministry of the Environment National public health and veterinary institutions Professional organizations Healthcare settings Healthcare payers Academic and scientific institutions NGOs Media	. Pre-existing National reference laboratory . To establish national AMR and AMU surveillance systems	. Engaged in several collaborations with WHO and European networks and institutions (ECDC, EARSS; ESAC),	. To publish annual reports on NAP progress, . To collect data on AMR and AMU
Democratic Republic of Korea (North Korea)	English	2018	2022	To reflect the five principles outlined by the Global Action Plan on AMR	Ministry of public health Ministry of Agriculture Ministry of Finance Education committee State quality control committee	. Pre-existing national AMR surveillance system, data collected and submitted to MoPH . Pre-existing national AMR reference laboratory . To establish and integrated AMR and AMU surveillance system in human and non-human health	. Signee of Jaipur declaration, . Support from WHO regional office to dress NAP, . Support from WHO regional office and FAO to dress	. To generate reports on AMR . To generate annual or biennial reports on AMU

					Mass media WHO FAO World Customs Organization	. To strengthen lab capacity, . To establish networking platform to share and exchange AMR information, . To establish HAI surveillance system	situational analysis . To organize international training for staff involved in AMR AMU data analysis, . To share AMR data with GLASS	
Egypt	English	2018	2022	To minimize the morbidity and mortality rates through control of AMR by raising public health awareness, strengthen infection control measures, containment of the emergence and spread of AMR organisms, activate lab-based surveillance system, rational use of antimicrobials and finding novel therapies.	Ministry of health and population, Ministry of agriculture WHO FAO	. Pre-existing national HAI surveillance system, . Two national reference labs provide EQS, . To establish a national AMU surveillance system in humans and animals, . To optimize AMU in agriculture . To strengthen laboratory capacity, . To establish and strengthen Amr surveillance system in human and animal sectors, . To develop a central network to collect AMR data and establish electronic networking between laboratories and surveillance units, . To test for AM residue in foods,	. Support from WHO to develop NAP, . Support from US CDC and USAID for national HAI surveillance system, . AMR data shared with GLASS, . To encourage partnership with international research institutes,	. AMR data collected and shared with GLASS, . To generate annual AMU reports in humans and animals, . To monitor NAP progress,
Ethiopia	English	2015	2020	To prevent, slow down, and contain the spread of AMR through the continuous availability of safe, effective, and quality-assured antimicrobials and their effective use thereof.	Ministry of Health Ministry of Agriculture Ethiopian Health and Nutrition Research Institute National Animal Health Diagnostic and Investigation Centre Universities WHO US Centers for	. First strategy adopted in 2011, this is an update, . To establish and strengthen a national integrated AMR surveillance system in humans, animals, and food health, . To establish a network for data sharing surveillance between all human and animal sectors, . To improve laboratory capacity, support testing standardization and ensure quality control,	. Support from the US agency for international development on NAP development, . To strengthen regional and international Networks and Collaborations on AMR to support research and	. To report AMR data in humans and animals . To report AMU data in humans and animals,

					Disease Control Ethiopia US Agency for International Development Healthcare associations	. To monitor AMU in humans and animals,	harmonize data submission, . To partner with other nations to promote quality, safety, and efficacy of antimicrobials and strengthen country pharmaceutical supply chains,	
Finland	English	2017	2021	To maintain antimicrobial medicines efficacious in Finland.	Ministry of Social Affairs and Health Ministry of Agriculture and Forestry Ministry of the Environment Ministry of Education and Culture	. Pre-existing AMR and AMU surveillance system in animals and humans, but no environment, and no integration. . To build and integrated One Health national surveillance system that monitors emergence of resistance and AMU in humans and animals, . To develop information system for AMR and AMU data collection and sharing, that allow for itemized analysis. . To enhance labs ability to adopt international standards, . To continue and strengthen monitoring of AMR in animals,	. Member of EARS-NET and GLASS, . To collaborate with international institutions on the fight against AMR and support research,	. To monitor NAP progress through annual reports, . AMR and AMU data is collected and reported,
France	French	2016		The durable reduction of AMU and AMR	Ministère des Affaires étrangères et du Développement international Ministère de l'Environnement, de l'Energie et de la Mer (MEEM) Ministère de l'Éducation nationale, de l'Enseignement supérieur et de la Recherche (MENESR)	. A first National alert plan on antimicrobials was developed in 2011, . Pre-existing national surveillance system on AMR and AMU in human and animal health, but efficiency under question, . To strengthen surveillance systems through the development on new indicators to measure resistance and exposure to AM in humans, animals, and the environment, . To integrate the surveillance of all	. One Health approach adopted in collaboration with many international bodies: EU, WHO, FAO, OIE… . To align national AMR research efforts with regional and international actions and to support research focused on public-health,	. To generate and report data on AMR and AMU annually,

					Ministère des Finances et des Comptes Publics (MFCP) Ministère des Affaires sociales et de la Santé (MASS) Ministère de la Défense (MDef) Ministère du Travail, de l'Emploi, de la Formation professionnelle et du Dialogue social (MTEFD) Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt (MAAF) Ministère de l'Économie, de l'Industrie et du Numérique (MEF) Ministère de la Ville, de la Jeunesse et des Sports (MVJS)	sectors and strengthen interministerial coordination on AMR control,	. To develop a network for AMR monitoring in LICs in collaboration with WHO and OIE,	
Germany	English	2015	2020	To combat and reduce in AMR in human and veterinary medicine (DOUBLE CHECK)	the Federal Ministry of Health the Federal Ministry of Education and Research the Federal Ministry of Food, Agriculture and Consumer Protection WHO OIE The European Commission	. The German Antimicrobial Resistance Strategy (DART) was first created in 2008, . Pre-existing national AMR surveillance systems in humans and animals, . Pre-existing national AMU surveillance system in humans . To expand the animal and human AMR surveillance systems to achieve complete surveillance, . To expand overall AMU surveillance in humans,	. Lead supported of the WHO in the implementation of the GAP, . Responsible for adding AMR on the agenda of the G7 summit in 2015, . To develop bilateral cooperation with select partner states in order to support GAP implementation,	. Annual GERMAP report on AMR and AMU in human and animal health,

					The GHSA and G7 states, Hospitals and laboratories Universities, academies, scientific institutions The pharmaceutical industry	. To further tighten rules of AM use in animals and to continue recording of quantities supplied to veterinary surgeons, . To strengthen laboratory network and national reference centers, . To develop alert and notifications mechanisms for early detection of resistance in humans and animals,	. To introduce measures encouraging prudent use of AM worldwide,	
Ghana	English	2017	2021	To reflect the five principles outlined by the Global Action Plan on AMR	Ministry of Health Ministry of Food and Agriculture Ministry of Environment, Science, Technology and Innovation Ministry of Fisheries and Aquaculture Development Ministry of Education Ministry of Trade and Industry Ministry of Justice Ministry of Interior Ministry of Water Works and Housing Ministry of Defense Ministry of Local Government and Rural Development WHO FAO Academia, Civil Society, Donors/Development Partners and Private Sector	. Existing national surveillance system for TB and HIV . To establish national surveillance systems for AMR in humans, animals, and environment, . To establish national surveillance systems for AMU in humans and non-human health, . To strengthen lab capacity to monitor resistance and standardize diagnostics and testing protocols, . to develop a national database and tools for communication and AMR/AMU data sharing, .	. Support from WHO and FAO for NAP development,	. To publish quarterly monitoring reports on AMU in veterinary and aquaculture, . To share AMR research that can inform policy, . To monitor NAP implementation bi-annually, . To share AMR surveillance data
Greece	Greek	2008	2012	The reduction of microbial resistance	Ministry of Health and Social Solidarity	. To adopt indicators to improve surveillance of AMR and HAIs in	. To promote cooperation and	. Annual NAP progress reports,

				to antibiotics by 50% by 2012 and to reach a level comparable to that of the rest of Europe	Public health and veterinary schools Research institutes Ministry of Rural Development and Food Healthcare professionals	healthcare, . To monitor AMU through a data collection system in public and private hospitals, . To expand AMR surveillance system nationally and to primary care and work on interconnecting hospitals and laboratories to enable real time data sharing, . To upgrade laboratories and standardize testing methods, . To develop and implement a national system for early detection and surveillance of HAIs, . To establish a network to record AMR in animals and agriculture, . To keep inventory of AMU in animals,	scientific collaboration with the EU, the WHO, and other international organizations,	
India	English	2017	2021	To effectively combat antimicrobial resistance in India and contribute towards the global efforts to tackle it, as well as establish and strengthen governance mechanisms and stakeholders' capacity to reduce the impact of AMR in India	Ministry of Health and Family Welfare Ministry of Food Processing Industries Ministry of Environment, Forest, and Climate change Ministry of Information and Broadcasting Ministry of Finance Medical and pharmaceutical councils Healthcare professionals and experts WHO FAO OIE UNEP	. Pre-existing national policy for containment of antimicrobial resistance published in 2014, . Pre-existing national AMR surveillance network in humans: INSAR, . To strengthen lab capacity for AMR surveillance and define national reference labs in humans, animals, food, and the environment, . To strengthen the national AMR surveillance system in all sectors and establish an online database available to all stakeholders, . To establish a national AMU surveillance system in humans, animals, and food	. Signee of Jaipur declaration, . Technical support to develop NAP, . To enroll in GLASS network, . To strengthen international cooperation and work with other countries to combat AMR,	. To report AMR data to GLASS, . To publish annual reports on AMR surveillance, . To publish annual reports on AMU surveillance,

Indonesia	English	2017	2019	To reflect the five principles outlined by the Global Action Plan on AMR	Ministry of Health Ministry of Defense Ministry of Agriculture Ministry of Research, Technology and Higher Education Ministry of Education Ministry of Information and Communication NGOs Academics Hospital and Professional Associations Pharmaceutical companies FAO WHO	. To set up an integrated national surveillance system for AMR in humans, animals, food, and aquaculture that allows early detection of resistance, . To carry our AMR surveillance in the environment, . To set up HAI surveillance system and integrate it with AMR surveillance, . To set up AMU surveillance system in humans, animals, and detection of AM residue in food, . To enhance laboratory capacity and identify National Reference Laboratories that carry out external quality assurance . To develop standard AMR surveillance guidelines,	. Support provided by WHO to dress situation analysis, . Technical support provided by WHO country and regional office and FAO to dress situation analysis and develop NAP, . To expand the nation surveillance laboratory network to establish regional and international networks (GLASS, GFN), . Support provided by WHO FAO OEI to establish a national IPC program, . To establish collaboration with international agencies on AMR research	. To report AMR surveillance data, . To report IPC data, . To report AMU data, . To report AMR trends to GLASS
Iran (Islamic Republic of)	English	2016	2021	To reduce the emergence and spread of resistant microorganisms and facilitate continuous and permanent access to antimicrobial agents and drugs which are effective in the prevention and treatment of diseases	Ministry of Health and Medical Education Health organizations Research institutes Ministry of Science, Research and Technology Ministry of Interior Ministry of Education Ministry of Agriculture Ministry of Cooperatives, Labor,	. HAI surveillance system established in 2007, . National committee on rational drug use, . National AMR surveillance system extended to private hospitals, . To strengthen national AMR surveillance system in humans, . To strengthen HAI surveillance system, . To monitor AMU trends in humans and to study the feasibility of integrating an AMU surveillance system with HAI surveillance	. Support from WHO for NAP, . To promote international collaboration on AMR research and new drug development, . To share data with GLASS	. To publish annual AMR surveillance reports, . To publish annual AMU surveillance reports, . To report on NAP progress, . To share data with GLASS

					and Social Welfare Ministry of Culture and Islamic Guidance Ministry of Industry, Mine and Trade Media	system, . To develop and strengthen AMR surveillance in animal health: Vet medicine, livestock, poultry, and aquaculture, . To strengthen lab capacity of monitoring and testing, to standardize protocols and methods and strengthen quality control, . To create a network to collect and share data that integrates all sectors: human health, animals, environment, and food, . To integrate the GLASS with the infectious disease surveillance system		
Iraq	English	2018	2022	Our goal is to prevent, slow down, and contain the spread of AMR through the continuous availability of safe, effective, and quality-assured antimicrobials and sets out a comprehensive roadmap to deal with AMR in Iraq	Ministry of Health / Environment Ministry of Agriculture. Ministry of Higher Education & Scientific Research Ministry of Municipalities and Public Works Ministry of Defense Ministry of Interior Popular Mobilization Forces The Ministry of Industry Pharmacists Syndicate Medical Syndicate Veterinaries Syndicate	. To establish an antimicrobial surveillance system in human, foods, animals, and the environment, . To generate a multi-sector information sharing system in humans, animals, and the environment, . To build lab capacity, identify a national reference lab and assure external quality assurance, . To test foods for AM residue, . To establish a system for HAI surveillance, . To ensure optimal use of AM in humans and animals through establishing a management committee of antibiotics in human and animal health,	. Technical support from WHO regional office to develop NAP, . To share data with GLASS,	. To report to GLASS . To publish annual reports on AMR surveillance data, . To generate annual progress reports
Ireland	English	2017	2020	Our goal is to prevent, slow down,	. Ministry of Health, . Ministry of	. Pre-existing national surveillance for community AMU since 2003.	. Member of EARS-net,	. To report data to GLASS,

				and contain the spread of AMR through the continuous availability of safe, effective, and quality-assured antimicrobials and sets out a comprehensive roadmap to deal with AMR in Iraq	agriculture, food, and the marine, page 97	Data published bi-annually, . Pre-existing national surveillance of AMR in key pathogens causing bloodstream infections and C. Difficile, . Shared web-based national information system: CIDR. Is a repository of health information shared with partners and labs, . Pre-existing national surveillance system of AMR in animals since 2014, . National surveillance of AMU in animals in place, part of the European Surveillance of Veterinary AMC . To coordinate national surveillance of AMR across all sectors: human, animal, agriculture, and environment, . To strengthen and integrate national surveillance systems for AMR, AMU, and HAIs, . To develop and implement a national laboratory system with capacity to produce high-quality microbiological data for patient management and to support surveillance activities in both human and animal sectors. . To implement a national system for the collection of data on antimicrobial use	. Member of GLASS, . Collaborative partner of the EU JAMRAI, . Member of the EU Joint Programming Initiative on Antimicrobial Resistance,	. To report biannually on NAP implementation progress, . To produce joint AMR surveillance reports between animal and human health,
Italy	Italian	2017	2020	To provide a coordinated and sustainable One Health approach to address AMR at	. Ministry of health, . Ministry of education,	. Pre-existing AMR surveillance system and national database in healthcare, . To strengthen AMR surveillance in humans and animals, . To strengthen laboratory capacity	. To share AMR data with ECDC and WHO,	. Annual NAP progress reports, . To publish annual national AMR surveillance reports in human and animal

				national, regional, and local levels		and develop an alert mechanism for early reporting of new resistance profiles, . To develop IT solutions for data sharing between the veterinary and human sectors, . To implement a national HAIs surveillance system, . To monitor AMU in healthcare and veterinary sectors, . To monitor foods for AM residue,		health, . To publish annual epidemiological report on HAIs, . To publish annual AMU reports in human and animal health, . To publish integrated annual reports on human and veterinary AMR and AMU,
Japan	English	2016	2020	to minimize the emergence of AMR and prevent the spread of infectious diseases caused by antimicrobial-resistant organisms towards a world free of the burden of infectious diseases caused by AMR.	RELATED MINISTRIES AND AGENCIES Cabinet Secretariat (CAS), Food Safety Commission of Japan (FSC), Ministry of Foreign Affairs (MOFA), Ministry of Education, Culture, Sports, Science and Technology (MEXT), Ministry of Health, Labor and Welfare (MHLW), and Ministry of Agriculture, Forestry and Fisheries (MAFF), Ministry of the Environment (MOE) RELATED INSTITUTIONS National Institute of Infectious Diseases (NIID), National Veterinary Assay	. National AMR surveillance system in place since 2000 (JANIS), . National AMR and AMU surveillance system in animals in place since 1999 (JVARM), . National AMU surveillance system in inpatients in place, . To strengthen AMR surveillance system in healthcare, to establish robust surveillance of DRTB and Neisseria gonorrhoeae infections, and monitor AMR in nursing care facilities and outpatients, . To strengthen the HAI surveillance and link its data with JANIS to facilities assessment and management, . To develop surveillance methods to monitor AMU use in outpatients as well as inpatients and link data with JANIS, . To strengthen AMR and AMU surveillance in livestock production and aquaculture and introduce monitoring in pets and agriculture, . To integrate AMR surveillance in	. To disseminate AMR data and policy recommendations to international organizations likes WHO, . Joined the Global Research Collaboration for Infectious Disease Preparedness (GloPID-R) one of whose objectives is to accelerate international research collaboration on AMR, . To contribute to international research efforts on AMR to promote R&D globally and strengthen monitoring in healthcare and animals	. To continue reporting on AMR and AMU in healthcare and in animals, . To report on AMU in agriculture, . To produce annual One Health surveillance report on AMR, . To report annually on implementation progress, . To report AMR data to GLASS,

					Laboratory (NVAL), Japan International Cooperation Agency (JICA), Pharmaceuticals and Medical Devices Agency (PMDA), Fisheries Research Agency (FRA), National Agriculture and Food Research Organization (NARO), Food and Agricultural Materials Inspection Center (FAMIC), National Center for Global Health and Medicine (NCGM), Japan Agency for Medical Research and Development (AMED), Japan Council for Quality Health Care	humans and animals, . To strengthen lab capacity and standardize testing methods in all sectors, . To establish a One Health surveillance system that integrates all sectors and monitors AMR and AMU, . To align national monitoring projects with GLASS,	. To support WHO AMR control measures in the Asia Pacific region and work to implement the GAP, . To align	
Jordan	English	2018	2020	To reduce the mortality, morbidity, and economic impact of AMR in Jordan through establishing policies and national multi-sectoral mechanisms that support an effective and sustained AMR management system	Ministry of Health Ministry of Agriculture JFDA: Jordan Food and Drug Agency JPA: Jordan Pharmacists Association J-RMS: Jordan Royal Military Service JMA: Jordan Medical Association JDA: Jordan Dentists Association 8. The Higher Health Council 9.	. To establish a national One Health surveillance system for AMR that allows data collection, management, networking, and dissemination of information in a real-time manner, . To strengthen laboratory capacity, unify testing standards and guidelines and promote quality assurance, . To strengthen the AMR and AMU monitoring system in poultry, . To establish a national HAI surveillance program, . To establish a national AMU surveillance system in local	. Support from WHO and FAO to finalize NAP, . GLASS participant,	. To publish NAP progress reports, . To produce yearly AMR and AMU report through the national electronic health system,

					JVA: Jordan Veterinarians Association 10. Ministry of Environment 11. HCAC: Health Care Accreditation Council	hospitals and regulate AMU in animals,		
Kenya	English	2017	2022	The goal of this National Action Plan is to ensure, for as long as possible, continuity of successful treatment and prevention of infectious diseases with effective and safe medicines that are quality-assured, used in a responsible way, and accessible to all who need them.	Ministry of Health Ministry of Agriculture, Livestock, Fisheries and Blue Economy Ministry of Education Science and Technology Ministry of Environment and Natural Resources National Treasury Ministry of Industry, Trade and Cooperatives WHO FAO The UK Department of Health under the Fleming Fund. The US CDC The Center for Disease Dynamics Economics and Policy through Global Antibiotic Resistance Partnership	. To develop a National One-Health Surveillance system to monitor AMR in humans, animals, food, and the environment, . To strengthen lab capacity and standardize testing methods, . To develop an IT platform to enhance data sharing and communication, . To develop a national surveillance system to monitor AMU and AMR in animals and the environment as well as track AM residue in foods, . To develop a national HAI surveillance system, . To develop a centralized surveillance system for AMU	. Support from WHO, FAO, the Fleming Fund, the US CDC, the Center for Disease Dynamics Economics and Policy	. To publish reports on AMR status, . To publish a midterm and end of term report on NAP progress, . To generate reports on AMU
Liberia	English	2018	2022	The goal of this National Action Plan is to prevent and control the spread of resistant	Ministry of Health (MoH) National Public Health Institute of Liberia (NPHIL)	. To strengthen lab capacity and participate in GLASS and establish an early warning system to determine AMR risk factors, . To establish an integrated national	. Support from CDC, FAO, USAID, WHO to develop NAP, . GLASS participant,	

				organisms while ensuring continuity of successful treatment and prevention of infectious diseases with effective, safe, and quality-assured antimicrobials.	Environmental Protection Agency (EPA), Liberia Water and Sewage Corporation (LWSC), Ministry of Agriculture (MOA) Centers for Disease Control and Prevention (CDC), Food and Agricultural Organization (FAO) Mother Pattern College of Health Sciences United States Agency for International Development (USAID World Health Organization (WHO)	surveillance system for AMR in human and animal health and monitor foods for AM residue, . To establish a centralized management system for data sharing, . To establish a monitoring system of AMU in human and animal health,		
Lithuania	Lithuanian	2017	2021	to reduce antimicrobial resistance the potential for the emergence and spread of micro-organisms.	MoH	. To expand and improve systems for monitoring AMR, AMU, and HAIs,		. Yearly NAP progress report,
Luxembourg	French	2018	2022	To reduce the emergence, the development, and the transmission of AMR with a One Health approach	Ministry of Health, Ministry of Agriculture, Viticulture, and consumer protection,	. To improve the national AMU surveillance system in healthcare and establish a national surveillance system in animals, . To continue surveilling foods for AM residue, . To establish a national AMR surveillance system in humans and animals, . To reinforce national surveillance of HAI,	. Member of EARS-NET . Member of ESAC-NET . To create durable partnerships with European and international partners,	. To publish an annual report on AMU and AMR surveillance results, . To share data with GLASS, EARS and ESAC NET,

						. To create a centralized system for data collection and analysis.		
Malawi	English	2017	2022	A framework for managing AMR, limiting further increase in resistance, and improvement of patient outcome.	Ministry of Health, Ministry of agriculture, Ministry of Education, Ministry of Natural Resources, Energy and Mining, Ministry of Local Government, Ministry of Finance, Economic Planning and Development, Pharmacies, Civil society organizations,	. To strengthen national surveillance system of AMR in humans, animals, agriculture, and the environment, . To establish a mechanism for regular sharing of AMR data across human, animal health, agriculture, and environmental sectors. . To monitor antimicrobial prescription,	. Financial support from Fleming Fund, . To participate in international collaborative research that support the development of new medicine, diagnostic tool, and vaccines.	. To monitor NAP progress through annual reports, . To report on AMR and AMU on a monthly, quarterly, and annual basis through the HMIS
Malaysia	English	2017	2021	To slow the emergence of AMR and prevent its spread through four key priority areas	Ministry of Health Ministry of Agriculture and Agro-based Industry Ministry of Higher Education Ministry of Defense Hospitals Private Healthcare facilities Community Pharmacists The Animal Food Industry Human and Animal health professional Organizations Universities NGOs	. National AMR surveillance system established with a national reference laboratory, . National AMU surveillance system established and extended to private hospitals, . National PPS conducted, . To strengthen the national AMR surveillance system and extend it to private hospitals and animals, and strengthen the national surveillance of HAI, . To develop and integrated AMR surveillance system in humans, animals, and food . To strengthen HAI surveillance and establish yearly PPS on community UTIs, . To strengthen AMU surveillance in humans and animals, . To adopt WHONET in participating	. To participate in WHO Integrated Global Survey on ESBL-producing E. coli using “One Health” approach, “The Tricycle Project”. . To establish a One Health surveillance system that promotes information sharing and participation in global networks.	. To publish AMR surveillance reports, . To report AM consumption sales data through International Medical Statistics (IMS),

						laboratories, . To standardize testing methods for AMR and enroll in Quality assurance program provided by the central reference lab, and establish early AMR detection methods,		
Maldives	English	2017	2022	to ensure, for as long as possible, continuity of successful treatment and prevention of infectious diseases with effective and safe medicines that are quality-assured, used in a responsible way, and accessible to all who need them	Ministry for Health Ministry for Fisheries &Agriculture Ministry of Education Ministry of Commerce Ministry of Finance Ministry of Information and Broadcasting Professional associations International organizations (WHO/FAO/OIE)	. To establish a One Health integrated surveillance system in Humans and animals, . To develop an integrated human and animal IT platform for data entry, storage and sharing, . To build laboratory capacity under the leadership of a national reference center, and to standardize testing methods, . To integrate HAI surveillance network into National AMR surveillance system, . To design an AMU and residue monitoring program in humans, animals, and food industry; develop guidelines to implement residue testing, . To conduct integrated AMU and AMR analysis,	. Technical and financial support from WHO to undertake situation analysis and develop NAP, . To report to GLASS one formal linkage between national AMR surveillance system and GLASS is established (21-22)	. To generate AMR and HAI reports, . To generate AMU reports,
Malta	English	2018	2025	To ensure the efficacy of antibiotics for the long term via the appropriate use of antibiotics and minimizing the development and spread of AMR	Ministry of Health Ministry of the environment, sustainable development, and climate change, Ministry of education, Healthcare professionals, Pharmacies and pharmaceutical industry, Farmers and	. Pre-existing national AMR surveillance system in hospitals, . To strengthen and integrate AMR and AMU surveillance surveillance both in human and animal health, . To strengthen reference laboratory capacity and increase access to microbiology support for primary care and veterinary services.	. Member of EARS-NET, . Member of ESAC-NET, . To strengthen international partnerships and collaboration on regional, European, and global efforts to respond to AMR,	. To produce annual AMR and AMU report,

					professionals in animal health, European Centre for Disease Prevention and Control			
Mauritius	English	2017	2021	to promote and ensure the prudent and judicious use of antimicrobials in the human and agricultural sectors with emphasis on the promotion of infection prevention and control, in an endeavor to slow down the rate of development and spread of antimicrobial resistant microorganisms, and to ensure that antimicrobials remain a viable option in the management of infectious diseases	Minister of Health and Quality of Life Ministry of Agro-Industry and Food Security Ministry of Ocean Economy, Marine Resources, Fisheries and Shipping Ministry of Social Security, National Solidarity and Environment and Sustainable Development WHO	. To set up a national electronic surveillance system for AMU and AMR in humans and animals, . To build laboratory capacity and designate a national reference lab for surveillance of antimicrobial use and resistance in human, animal and environmental health sectors with standard operating procedures and external quality assessment, . To institute HAI surveillance	. Technical support from WHO to develop NAP, . To participate in GLASS, . Received external funding to implement NAP,	. To share AMR data on GLASS, . To generate annual reports on AMR, . To report on AMU data,
Myanmar	English	2017	2022	To reflect the five principles outlined by the Global Action Plan on AMR	Ministry of Health and Sports Ministry of Agriculture, Livestock, and Irrigation Ministry of Education Ministry of Commerce Ministry of Home Affairs Ministry of Defense	. To Identify and establish a reference laboratory, . To set up a national surveillance system for AMR based on a quality assured national laboratory surveillance network, . To set up surveillance standards that incorporate GLASS and other intergovernmental standards, . To establish systemized and standardized processes for data	. Situational analysis done with help from WHO regional office, . International cooperation set up with global centers of excellence in research, . Reporting to GLASS; . Collaboration with WHO, FAO, OIE on	. To publish AMR data reports, . To publish reports on the performance of the national AMR surveillance system, . To publish reports on the performance of the national reference lab and the lab network,

					non-governmental agencies, cooperatives, civil society representatives, media, international agencies (WHO/FAO/OIE)	collection and sharing, . To set up a national AMU surveillance system in human and animals, . To monitor foods for AM residue	policy design, intervention evaluation and development of surveillance guidelines and standards, . To develop research collaborations on AMR	. To publish reports on national IPC program, . To publish reports on AM sales
Nepal	English	2016		To protect Nepalese from the health risks related to antimicrobial resistance	Ministry of Health Ministry of Agriculture Ministry of Livestock Development, Academics WHO	. To strengthen the existing surveillance systems to identify new threats or changing patterns in antimicrobial resistance and use, in human and animal settings, . To integrate the veterinary, livestock, and agriculture with the national AMR network,	. WHO provides support to the national public health laboratory since 2006,	. Regular dissemination of AMR data by the national public health laboratory (Monthly, quarterly, and annually)
Netherlands	English	2015	2019		Ministry of Health, Ministry of Welfare and Sport Ministry of economic affairs,	. Pre-existing AMR and AMU national surveillance systems, . To establish central coordination to strengthen control over infectious diseases. As well as improve early detection of and response to resistant bacteria, . To reduce the number of avoidable HAIs, . To reduce AMU in healthcare and in animals, . To draft an action plan to reduce the occurrence of resistant bacteria and antimicrobials in the environment,	. Involved with the Global Health Security Agenda with a focus on AMR and zoonotic diseases, . Provides technical support and guidance to other countries to implement AMR control strategies, . Financial support to WHO in the realization of the GAP,	. To report on AMR, AMU, HAI
Nigeria	English	2017	2022	To reduce, prevent and slow the evolution of resistant organisms and their impact on healthcare while	Ministry of Health Ministry of Agriculture and rural development Ministry of Environment	. To set up a One Health national surveillance system for AMR, . To build laboratory capacity, identify a national reference laboratory and standardize testing in all sectors (human, animals, food,	. Member of GLASS, . Technical support from WHO, CDDEP, the African Field Epidemiology Network for situation	. To contribute national surveillance data to GLASS, . To generate AMR data reports,

				ensuring optimal use and improved access to effective, safe, and quality assured antimicrobials for continued successful management of infections.	WHO CDDEP African Field Epidemiology network Academics	and environment), . To implement a unifying platform for multisectoral data management, . To develop surveillance for HAI,	analysis and to develop NAP,	. To publish annual HAI report,
Norway	English	2015	2020	to reduce the total use of antibiotics and to assure responsible use of antibiotics in all sectors, to increase the body of scientific knowledge, and to be an international mobilizer against antibiotic resistance.	Ministry of Health and Care Services Ministry of Fisheries Ministry of Agriculture and Food Ministry of Climate and Environment	. Pre-existing AMR and AMU national surveillance systems in healthcare and animals, . To reduce AMU in healthcare, animals, and fish, . To map resistant bacteria in the environment,	. To support the regulatory role of WHO, FAO, OIE in AMR, . To work with other countries to promote an approach that enhances access to and use of AM, . To work on regulation regarding AM use in animals and	. To continue reporting on AMR and AMU in healthcare and in animals,
Oman	English	2016		To combat antimicrobial resistance through nationally coordinated efforts between different sectors and stakeholders	Ministry of Health Ministry of Agriculture and fisheries Ministry of Municipality Ministry of Environment Hospitals, pharmacies, and universities Media	. To upgrade laboratory capacity, standardize testing methods and ensure quality control, . To adapt a national AMR surveillance using the GLASS framework, . To conduct point prevalence studies at the animal and agriculture sectors, . To monitor AMU trends in humans and animals,	. To collaborate and participate in global networks for expertise exchange and research,	. To collect and report data on AMR and AMU in animals and humans,
Pakistan	English	2017		To have a functional coordinated, collaborative, and sustainable AMR	Ministry of National Health Services, Regulations and Coordination	. To establish an integrated national AMR surveillance system (human, animal usage and resistance monitoring),	. To participate in GLASS,	. To report on AMU, . To report on AMR and share with GLASS,

				containment system in place using “One Health” Approach aligned with WHO Global Action Plan on AMR.	Ministry of National food security and research Medical and pharmaceuticals associations and hospitals WHO	. To develop a functional AMR network in all sectors according to GLASS protocols, . To regularly monitor antimicrobial sale and utilization at all levels and sectors, . To strengthen AMR surveillance capacity, define national and regional quality assured reference labs and standardize testing in all sectors, . To establish a common dashboard for data sharing among public and private stakeholders from district to provincial to national level,		
Philippines	English	2015	2020	To implement an integrated, comprehensive, and sustainable national program to combat AMR geared towards safeguarding human and animal health while preventing interference in the agricultural, food, trade, communication, and environmental sectors	Department of Health (DOH) Department of Agriculture (DA) Department of Science and Technology (DOST) Department of the Interior and Local Government (DILG) Department of Trade and Industry (DTI) WHO FAO OIE ASEAN	. National AMR surveillance program established, allows sharing of data on emerging resistance and guides treatment, . Reference laboratory already established . To strengthen laboratory capacity, establish standards and train personnel in human and animal health . To strengthen the implementation of HAI surveillance . To develop an integrated surveillance system for AMR, AMU, and HAI in human and animal health . To develop an IT platform to share AMR data with stakeholders	. Technical support provided by WHO, FAO, OIE, ASEAN . Support for situational analysis provided by WHO regional office . Collaboration with the Asian Network for Surveillance of Resistant Pathogens (ANSORP), . Funding and technical support to ANSORP provided by the Asia Pacific Economic Cooperation (APEC) . Collaboration with the Ministry of Health Malaysia in the conduct of a rapid assessment for	. To generate IPC monitoring reports in human and animal health, . To generate annual AMU and AMR reports in human and animal health, .To general annual integrated report on AMU, AMR, and HAI

							regulatory measures to combat AMR	
Poland	Polish	2016	2020	To rationalize the use of antibiotics in medicine and thus inhibit the rise of drug resistance in Poland and to implement programs in this area in accordance with the directives of the Council of the European Union.	Ministry of Health Ministry of Agriculture and Rural Development Medical societies and entities Research institutes WHO	. To monitor AMU in healthcare, . To update testing standards in laboratories, . To monitor select alarm pathogens relevant within the EARS-Net,	. Member of EARS-Net and ESAC-Net, . Support to implement NAP from European Commission, ECDC, WHO, EARS-Net and ESAC- Net, EMGM, EMERT	. Yearly reports on AM susceptibility of select pathogens shared with EARS-Net, . Yearly reports on AMU shared with ESAC-Net,
Republic of North Macedonia	English	2012	2016	improvement of the health status of the population in RM and securing the quality health protection at all levels, through the AMR control.	Ministry of health Ministry of education Health institutions and hospitals,	. To establish programs for AMR control in the hospitals as well as systems for monitoring AMU, . To update the AMU monitoring system in animals, . To define a national reference laboratory for AMR monitoring and improve testing capacities,	. To encourage collaboration with international agencies on AMR control, . Explore cooperation with WHO and ECDC to monitor AMR and exchange data,	
Saudi Arabia	English	2017		To reflect the five principles outlined by the Global Action Plan on AMR	Ministry of Health Ministry of Environment, Water, and Agriculture Ministry of Education Ministry of Defense-Health Affairs Ministry of Interior – Health Affairs Ministry of National Guard - Health Affairs Ministry of Culture and Information Hospitals, universities, and medical societies	. To set up a national surveillance system for AMR in humans and animals, . To establish IT systems for AMR data monitoring and data sharing, . To build laboratory capacity to produce high-quality microbiological data in both human and animal sectors	. Member of GLASS,	. To report AMR data to GLASS, . To publish annual reports on AMR surveillance, . To publish annual reports on AMU surveillance,

South Africa	English	2018	2024	to provide a structure for managing AMR among humans and animals to limit further increases in resistant microbial infections and improve the health of the population.	National Department of Health Department of Agriculture, Forestry and Fisheries Department of Trade and Industry Department of Science and Technology Department of Education academia and universities Medical and pharmaceutical societies	. To strengthen the existing national surveillance system to improve understanding of resistance trends and AMU in humans and animals, . To introduce a national longitudinal surveillance system of AMR and AMU in animals, .	. To share AMR data with GLASS and OIE database to improve knowledge on the topic,	. Data sharing with GLASS,
Sri Lanka	English	2017	2022	To promote infection prevention and control, to promote rational use of antimicrobials and to ensure the availability of safe and effective antimicrobials of good quality	Ministry of Health Ministry of Rural Economy Ministry of Fisheries and Aquatic Resources Development Ministry of Agriculture healthcare professionals and public Ski Lanka college of Microbiologists World Health Organization	. To strengthen/establish a national surveillance system for AMR in human and animal, . To establish/strengthen national surveillance system for AMU in human, animal, aquatic products, food industry and agriculture, . To build laboratory capacity to produce high quality microbiological data	. Technical and financial support from WHO to develop NAP,	. To report on NAP progress, . To establish AMR and AMU databases,
Sudan	English	2018	2020	To retain and develop national capacities for the prevention and control of AMR	Federal Ministry of Health Federal Ministry of Animal Resources Ministry of Environment and	. To establish a National Surveillance System of AMR in Sudan to include the Ministries of Health, Animal Resources, Agriculture, and Environment, . To build the capacity of the	. Technical and financial support from WHO, FAO and OIE to develop NAP, . Joined GLASS	. To generate reports on priority AMR pathogens, . To general monthly HAI reports,

				through one health approach	Ministry of Educations WHO FAO International Organization for Animal Health	National Reference laboratory for human and animal sectors, . To establish an HAI surveillance system in integration with the national AMR surveillance system, . To monitor AMU in health institutes		. To generate annual AMU reports,
Sweden	English	2016		Preserve the possibility of effective treatment of bacterial infections in people and animals	Minister for Health Care, Public Health and Sport Minister for Rural Affairs Minister for Higher Education and Research	. Pre-existing AMR and AMU surveillance systems, . To strengthen surveillance through continuous data reporting and sharing, and efficient systems for early detection and analysis,	. To share data at the EU and international level, . To take part in international research collaboration, . To support WHO, FAO, OIE in efforts to combat AMR, . To work towards a global integrated surveillance system in animals and humans and food,	. To continue reporting AMR and AMU data,
Switzerland	English	2015		To ensure the long-term efficacy of antibiotics in preserving human and animal health.	Federal Office of Public Health Federal Food Safety and Veterinary Office Federal Office for Agriculture Federal Office for the Environment Swiss Conference of Cantonal Ministers of Public Health (CMPH), learned societies, expert groups, industry, various sectors and associations	. Pre-existing AMR and AMU surveillance systems in humans and animal health, . To develop an integrated, comprehensive monitoring system of AMR and AMU in human, animal, and environment health, . To develop and expand a network of reference laboratories for standardized investigation of AMR, . To develop and implement systems for monitoring, preventing, and combating HAIs,	. To set up and intensify support for developing countries in combating antibiotic resistance, . To strengthen links with other countries with regard to strategies, approaches, and research, . To continue collaborating with international bodies: OIE, WHO, FAO, EFSA and the EU Commission, . To share data with	. To publish annual reports on AMR and AMU data,

							global networks like WHO Europe,	
Tanzania	English	2017	2022	To reflect the five principles outlined by the Global Action Plan on AMR	Ministry of Health WHO ++ Others	. To develop a National integrated AMR surveillance system for reporting and information sharing in humans, animals, plants, and environment, . To establish AMU surveillance in humans, animals, plants, and environment, and establish AM residual testing, . To build laboratory capacity to produce high-quality microbiological data	. Technical and financial support from WHO to develop NAP, . Technical support from FAO and the American society of microbiology, . Situation Analysis done with help from GARP,	. To establish a national a national AMR data repository, . To share annual reports on AMR and AMU data,
Thailand	English	2017	2021	To reduce mortality, morbidity, and economic impact of AMR Mission through policies and national multi-sectoral mechanisms which support an effective and sustained AMR management system	Ministry of Public Health Ministry of Agriculture and Cooperatives academia, professional societies, and civil society organizations WHO FAO	. To strengthen laboratory capacity and networking as well as their epidemiological capacity, . To establish and strengthen a national integrated surveillance system of AMR, AMU in human, animal, and agriculture, and extend it to both public and private sectors . To establish a national integrated surveillance system of HAI	. Support from WHO and FAO to establish NAP, . Partner of Jaipur declaration on AMR 2011	. Annual AMU consumption in humans and animals provided by the Food and Drugs Administration, . Reporting on reduction of bacteremia caused by 5 resistant pathogens in large hospitals.
United Kingdom of Great Britain and Northern Ireland (the)	English	2019	2024		Secretary of environment, food, and rural affairs, Secretary of Health and social care, Governments of Scotland, Northern Ireland, and Wales	. First NAP created in 2000. One Health perspective incorporated in 2013, . Tools and systems in place to monitors AMR and AMU in animals and humans, . To strengthen the prevention and control of infection in healthcare by adopting a systemic approach that reconsiders how infection spreads and focuses on surveillance, . To work on better understanding how AMR spreads between and	. Worked with WHO, FAO and OIE to secure commitment to the 2014 GAP and the declaration of the UN on AMR in 2016, . Provides technical and financial support to LMICs to develop NAPs and strengthen infrastructure, AMR surveillance, and health systems	. Published first UK One Health report in 2015: provides human and animal antibiotic use, sales, and resistance data for key zoonotic pathogens . Biennial One health reports

						among humans, animals, and the environment, . To optimize use of AM in humans, animals, and agriculture, . To strengthen laboratory capacity and harmonize AMR data collection and use in humans and animals,	(Fleming Fund), . Participates and shares data with a number of international networks: GLASS, EARS-Net, ESAC-Net, EVAC-Net and EFSA . Funds research initiatives on research and development of new technologies and knowledge to combat AMR, . To strengthen its role in global collaboration through adoption of international action on AMR and protecting stewardship and access to antimicrobials worldwide,	
United States of America	English	2015		To guide action by public health, healthcare, and veterinary partners in a common effort to address urgent and serious drug-resistant threats that affect people in the U.S. and around the world.	Secretary of Defense, Secretary of Agriculture, Secretary of Health and Human Services, Department of State, Department of Justice, Department of Veterans Affairs, Department of Homeland Security, Environmental	. To strengthen National One-Health Surveillance Efforts to monitor AMR and AMU in humans and animals, . To strengthen national capacity to detect resistant bacteria via a regional public health laboratory network and better national infrastructure in humans and animal health, . To develop new diagnostics and testing tools to detect resistance and make them widely available,	. To collaborate with WHO, OIE, and other international efforts on the development of integrated, laboratory-based surveillance and new therapeutics, . To support countries to develop and implement AMR NAPs, . To partner with	. To implement annual reporting of AMU in healthcare and food producing animals, . To implement routine AMR data reporting in healthcare

					Protection Agency, United States Agency for International Development, Office of Management and Budget, Domestic Policy Council, National Security Council staff, Office of Science and Technology Policy, National Science Foundation.		other nations to promote antibiotics safety and strengthen their pharmaceutical supply chains, . To coordinate with international organizations on regulation and harmonization of international data submission,	
Zambia	English	2017	2027	to provide a coherent framework for combating AMR using the "One Health" approach encompassing human, animal, plant, and environment in Zambia from 2017 to 2027.	Ministry of Health, Ministry of Fisheries and Livestock Ministry of Agriculture Ministry of Local Government Ministry of Water development, Sanitation and Environmental Protection Ministry of Information Professional organizations and Academia, Public universities and colleges UNDP WHO CDC DFID FAO OIE WORLD BANK IFAD EU SADC AU-IBAR USAID COMESA	. To integrate AMR surveillance into the national surveillance system (clinical and laboratory) for human, animal, plant, food, and environment, . To build laboratory network capacity to conduct AMR activities,	. Technical and financial support from WHO, FAO and CDC to develop NAP, . To promote national and international collaboration among industry, government, academia, and other institutions on AMR research,	. To publish and report National AMR surveillance data.

					UNICEF ADB DBZ ECSA-HC			
Zimbabwe	English	2017	2021	to reflect the five principles based on which the GAP AMR strategies have been enunciated.	Ministry of Health and Child Care Ministry of Agriculture Mechanization and Irrigation Development Ministry of Environment, Water and Climate World Health Organization (WHO), Food and Agriculture Organization (FAO) Centers for Disease Dynamics, Economics & Policy (CDDEP)	. To strengthen laboratory capacity, . To integrate the surveillance for humans, animals, and the environment into a 'One Health' integrated surveillance system, . Establish an AMU monitoring system for antimicrobials for human and animal use., . To strengthen HAI surveillance	. Financial and technical support from WHO, FAO, UN to develop NAP, . Support from GARP and Action on Antibiotics Resistance (ReAct) for situation analysis, . To share data with relevant international organization reporting systems: WHO, OIE, FAO, CDDEP.	. To report AMR surveillance data, . To publish annual one heath report,