THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Developing National Strategies to tackle Antimicrobial Resistance across countries in the Eastern Europe, Middle East and Africa (EEMEA) region

A pilot analysis of Egypt, Russia and South Africa

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We openly acknowledge that there is a subjective element to our analysis, which is vulnerable to misinterpretation. However, we do not aim to criticise the many well-intentioned and pre-existing efforts to tackle antimicrobial resistance (AMR) in Egypt, South Africa, and Russia, but instead aim to stimulate debate in each country how to strengthen AMR national action plans to facilitate sustainable implementation. We also acknowledge the fact that these three countries represent completely different types of healthcare systems, approaches to healthcare funding and medicines' reimbursement, and, above all, varied epidemiological landscapes. This was a deliberate decision to facilitate cross-country learning between countries that have AMR national action plans at different stages of development. Hence, comparisons between countries must be made with these caveats in mind, and our primary aim is to showcase how countries representing different regions are tackling rising global threat of AMR.

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Contents

Executive Summary

Antimicrobial resistance (AMR) is one of the greatest challenges facing the modern world, and the last decade has seen growing commitment at both international and national levels to develop sustainable policy responses to curb increasing levels of resistance. Following a recommendation by the World Health Organisation (WHO), [1] most countries have developed a national action plan (NAP) to tackle AMR but there is growing consensus that the greatest challenge is not just designing a national action plan (NAP) but implementing it. [2] To support these efforts, this project piloted applying a previously published AMR governance framework to the NAPs in Egypt, South Africa, and Russia, through a combination of reviewing publicly available literature and policy documents, and stakeholder interviews.

There are inevitable limitations to the work outlined in our report, and we wish to emphasise that our aim is not to criticise the many pre-existing and well-intentioned efforts to tackle AMR in each country, but instead to stimulate open and inclusive discussion regarding how policies to tackle AMR can be strengthened to enable sustainable action. AMR being a global challenge is tackled locally in countries with completely different healthcare systems, epidemiology and resources' availability. For these purposes three countries representing different regions of the world: Egypt (Eastern Mediterranean Region (EMR)), South Africa (African Region (AFR)) and Russia (European region (EUR)) were chosen and their strategies in AMR were studied. The below gives a summary of our findings and recommendations for change, but we encourage further review of our report for detailed analysis:

Policy Design

A strength of the Egyptian NAP is that it is ambitious and comprehensive, closely reflecting the five strategic objectives of the World Health Organisation (WHO) Global Action Plan on Antimicrobial Resistance (AMR), and takes the recommended One-Health approach to the development, implementation, and evaluation of activities to tackle AMR across human, animal, and environmental health. Moreover, activities are designed in a manner that is specific and measurable accompanied by deadlines, responsible officers/institutions, and an estimated budget. Broad participation of policymakers and academics across the One-Health spectrum was facilitated during development but there have been limited involvement of patient advocacy or non-governmental groups. However, the Egyptian NAP has not been widely disseminated, and, from our research appears to not have been followed by sustained action to implement contained actions.

The South African NAP is well developed and easily accessible. There are two iterations, the first published in 2014 and the second in 2018. Both take a comprehensive One Health approach addressing multiple levels of the human, animal and environmental health sectors. The NAPs are accompanied by implementation plans which include a timeline for achievement of the strategic objectives. In addition to the AMR NAP there is an IPC strategic framework, published in 2020, with an accompanying implementation plan. However, it is not clear to what degree civil society was involved in the development of the NAP. In addition, although funding is mentioned many times in the NAP, this is not quantified, and no recommendations are made regarding the establishment of sustainable funding streams.

Over the last 5 years the Russian government has shown an improved level of commitment to take action to curb the spread of AMR, evidenced by the publication of the national AMR strategy in 2017, and associated implementation plan in 2019 which is intended to guide government policy until the 2030s, and strengthened legislation in both human and animal health. The NAP does take a "One-Health" approach, and an associated implementation plan includes clear deadlines, and responsible ministries. However, some stakeholders feel the plan is still more focused towards human health and there has been less participation and engagement facilitated for stakeholders from animal and environmental health perspectives, as well as from patient advocacy groups during development.

Implementation Tools

In Egypt access to antimicrobials is not strictly regulated in either human or animal health, with access to antimicrobials without prescription commonplace. It has been challenging for Egypt to consider banning over the counter access to antimicrobials as many people of low income remain dependent on community pharmacists as a relatively affordable first point of contact for their healthcare needs. In animal health, the agricultural sector accounts for a significant proportion of the Egyptian economy, and is therefore a powerful stakeholder. In the Egyptian NAP, there is only a commitment to review current legislation governing the use of antimicrobials, rather than a clear high-level commitment to restrict the use of antimicrobials without a prescription in human health or the non-therapeutic use of antibiotics in animal health.

In South Africa, antimicrobials for human health are not available over the counter and clear national guidance exists for prescribing. However, poor regulation of prescribing in South Africa's substantial private sector is a problem which needs addressing. Hospital and Provincial antimicrobial surveillance committees have been established to guide and monitor antimicrobial prescribing and use, and there is a publicly available national antimicrobial resistance dashboard for the human sector, coordinated by the National Institute for Communicable Diseases. Additionally, a robust collaboration exists between public and private laboratories to pool data (GERMS-SA). In contrast, the animal and agricultural sectors are less well regulated. A limited number of antimicrobials remain available over the counter, mainly for the benefit of farmers in rural areas. There is no national surveillance of AMU or AMR in the animal or agricultural sectors, and the use of growth promoters is widespread. Although the NAP committed to a review of the non-therapeutic use of antimicrobials in the farming sector, this does not seem to have been undertaken yet.

Russia has developed multiple online repositories for surveillance data and analysis, including the AMRmap , and the AMRCloud, both of which are impressive examples of developing a transparent and publicly available data repositories for surveillance data and impressive methods for data visualisation. Despite acknowledgement at all levels that developing an integrated and interagency surveillance system would be a significant enabler for Russia's AMR Strategy, there is no clear implementation strategy or significant funding commitment needed to achieve this ambitious goal. While Russia has strengthened regulation of antimicrobials in animal health, some stakeholders feel that the use of prohibitions and penalties in animal health has not been combined with the necessary investment in promoting awareness and retraining of the workforce required for sustainable implementation of stewardship policies. Russia is accelerating research efforts into new treatments for communicable disease, in particular, alternative treatments such as bacteriophages, a historic treatment dating back to Soviet era Russia.

Monitoring and Evaluation

A strength of the Egyptian NAP is that it includes a monitoring and evaluation plan which includes specific quantitative targets and indicators to measure progress in achieving the stated objectives. However, from our research it appears that the publication of the Egyptian NAP has not been followed by sustained action, and the stakeholders interviewed were not aware of what mechanisms existed to report progress in achieving the stated objectives.

The South African NAP and accompanying implementation plan have timelines for achievement of the strategic objectives, and monitoring and evaluation indicators for a wide range of measures including AMU and AMR. The NAP details how feedback mechanisms exist between the hospital and provincial antimicrobial stewardship committees and the GERMS-SA nationwide network of clinical microbiology laboratories. We have been unable to find a publicly accessible progress report, therefore it is difficult to ascertain how well these mechanisms are working in practice or what progress has been achieved so far.

The publication of the Russian Strategy was followed by an implementation plan, which together form the Russian NAP, covering the period 2019-24, which details specific actions, responsible ministries, and

deadlines for achievement. However, as with Egypt and South Africa, it is challenging to monitor and evaluate progress in achieving Russia's stated objectives for tackling AMR as publicly available progress reports are not routinely published.

Recommendations for Change

There was consensus among the stakeholders interviewed that the Egyptian NAP has not been widely disseminated or followed by sustained action. Acknowledgement from high-level political leadership is necessary, followed by open discussion regarding the potential underlying factors. The subsequent NAP should receive prolonged ministerial support, and informed by a report detailing progress in achieving the previously stated objectives, actions, and deadlines. The biggest challenges facing Egypt are a lack of systematic surveillance of AMR and AMU rates, and poor regulation of access to antimicrobials in both human and animal health. Egypt needs to invest in surveillance systems to understand the extent of AMR at national, regional, and organisational levels. It should also commit to a timeline to introduce legislation to prohibit access to antimicrobials without a prescription in human-health, and for non-therapeutic purposes in animal health. However, this will need to be preceded by a broad consultation with affected stakeholders, including involvement of patient advocacy groups, and awareness and educational campaigns on AMR for the public, healthcare professionals, veterinarians and agricultural workers.

In South Africa, like many other countries, there is a need for a more balanced One Health Approach giving equal emphasis to animal, agricultural and environmental health. Conducting a budget impact assessment and allocating earmarked funding streams for the activities outlined in the South African NAP would support implementation. Clear lines of accountability must be established at all levels of the system, supported by clear, decisive leadership. A comprehensive workforce strategy is needed which takes into account each sector across the One Health spectrum, including laboratory staff, microbiologists, veterinary staff and staff involved in infection prevention and control. Surveillance must be strengthened and expanded to incorporate the animal and agricultural sectors, and feedback mechanisms must be reinforced so that prescribers across sectors are kept up to date with developments, and are supported in making prescribing decisions. Legislation should be introduced in the animal and agricultural sectors to address the non-therapeutic use of antimicrobials. Public awareness campaigns are urgently needed and these must be fully funded and tailor-made to suit different sectors and segments of the population.

Analysis showed that in Russia, more could be done to facilitate the involvement of patient advocacy groups and wider civil society in the development, implementation, and monitoring and evaluation of the Russian AMR NAP. The use of national and/or regional quantitative targets for AMR and antimicrobial usage could provide a mechanism to improve engagement around a common purpose, strengthen accountability and allow the transparent monitoring and evaluation. Developing a multi-year implementation strategy to create an integrated and interagency surveillance system would help facilitate feedback mechanisms regarding the achievement of targets of AMR and AMU rates at national, regional and organisational levels. In animal health, launching a nationwide educational campaign for veterinarians and agricultural workers on the issue of AMR would support recent legislative efforts to prohibit the use of antimicrobials for non-therapeutic purposes in agriculture. There is also a role for strengthened infection control and antimicrobial stewardship in animal health to tackle the challenges in intensive production of meat products, characterised by a high concentration of livestock, including the application of methods developed by the Scientific Consulting Center for the Development and Transfer of System Technologies in Veterinary Medicine and Agriculture (NCC RTST), such as optimising the use of diagnostics, vaccination, improved sanitation, and the substitution of antimicrobials for probiotics. In terms of research and development, Russia should consider partnering with other countries and international funders to secure necessary resources to fund both pre-clinical and clinical research into novel antimicrobials and alternative treatments such as bacteriophages. Finally, similar to Egypt and South Africa, producing publicly published progress reports would improve transparency and accountability in monitoring and evaluation.

1. Policy Background

Antimicrobial resistance (AMR) is driven by inter-related dynamics in the human, animal, and environmental health sectors and one of the most significant and complex current public health issues of our time. Without effective antimicrobials even common infections may become life-threatening and many treatments such as surgical procedures and chemotherapy will not be possible. [3,4] Today, drug-resistant pathogens are a challenge for all healthcare-systems; recent modelling of the health impact of AMR in European Union/European Economic Area (EU/EEA) countries has shown that approximately 670,000 infections occurred in 2015, responsible for just over 33,000 attributable deaths. The burden of infections with bacteria resistant to antibiotics on the EU/EEA population was comparable to that of influenza, tuberculosis and HIV/AIDS combined. [5] If not addressed, AMR is projected to cost the global economy up to EUR 90 trillion by 2050, due to losses in international trade or livestock production and increased healthcare expenditure. [6]

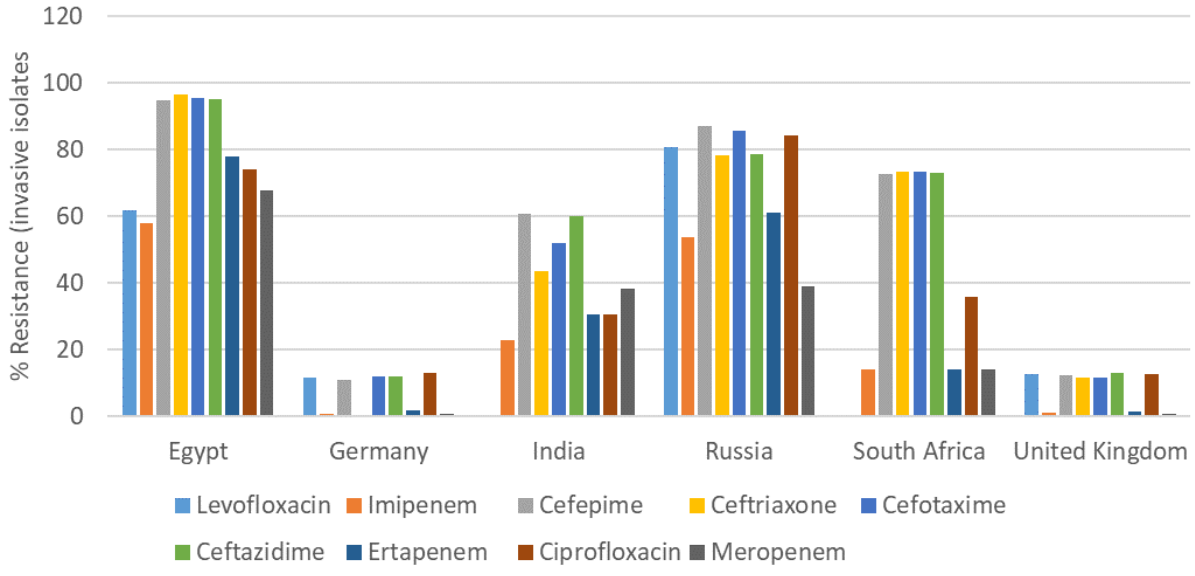
International and national efforts to combat AMR have grown steadily over the last two decades. Two major landmark developments include the launch of the World Health Organisation (WHO) Global Action Plan on AMR in 2015, which asks all countries to develop national action plans by 2017, [1] and the United Nations (UN) General Assembly agreeing a political declaration on AMR in 2016 where countries committed to work at national, regional, and global levels to develop and implement multisectoral national action plans in accordance with the 'One Health' approach.[7]

2. The European, Middle Eastern and African (EEMEA) Context

2.1 Rates of Antibiotic resistance

Data collated by the Center for Disease Dynamics, Economics & Policy from various sources including the WHO Global Antimicrobial Resistance Surveillance System (GLASS) and the Central Asian and Eastern European Surveillance of Antimicrobial Resistance (CAESAR), clearly shows that Russia, South Africa, and Egypt have much higher rates of antibiotic resistance than many high-income countries (Figure 1, 2).

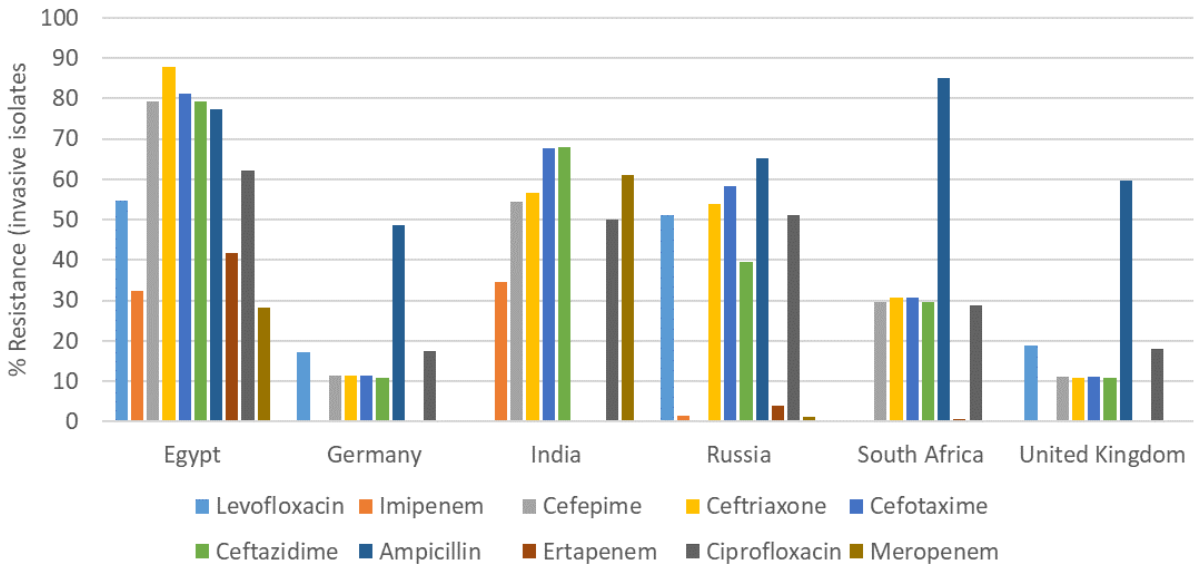
Figure 1: Antibiotic resistance of Klebsiella Pneumonia in selected countries (2019)



Source: WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS)[8]

Please see resistancemap.cddep.org for year and source of data

Figure 2: Antibiotic Resistance of Escherichia coli in selected countries (2019)

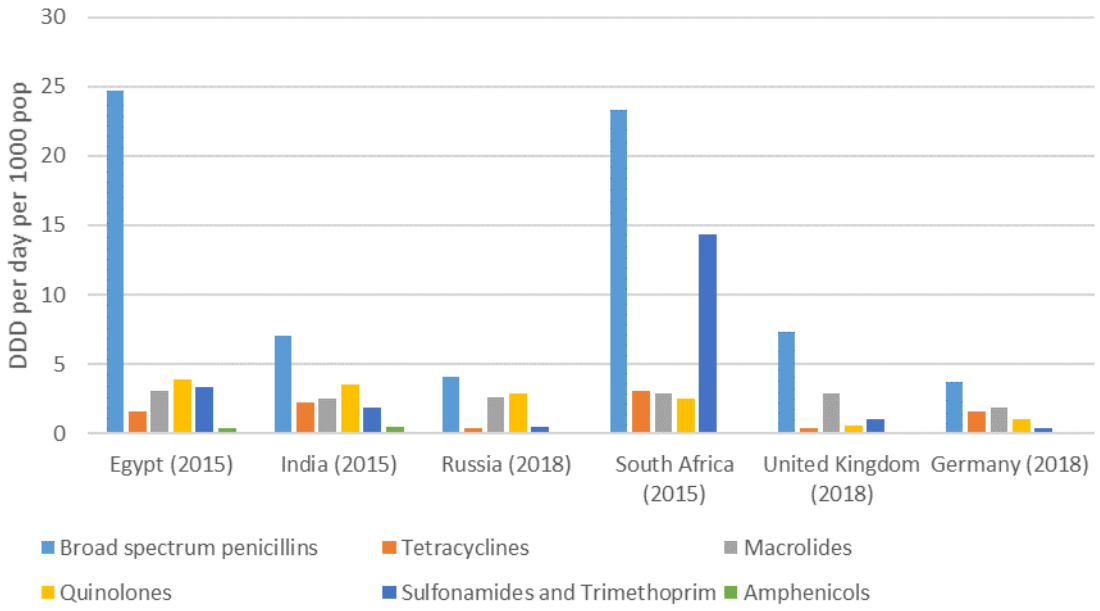


Source: WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS) [8]

2.2 Rates of antibiotic usage

Utilising data collected by Center for Disease Dynamics, Economics & Policy, WHO Regional Office for Europe Antimicrobial Medicines Consumption (AMC) Network, and the European Centre for Disease Prevention and Control, it can be demonstrated that antibiotic usage in Russia is similar to other selected high-income countries (Figure 3). However, consumption of broad spectrum penicilllins in particular is much higher in Egypt and South Africa than these comparator countries.

Figure 3: Antibiotic use for selected countries (2018, or latest available year)

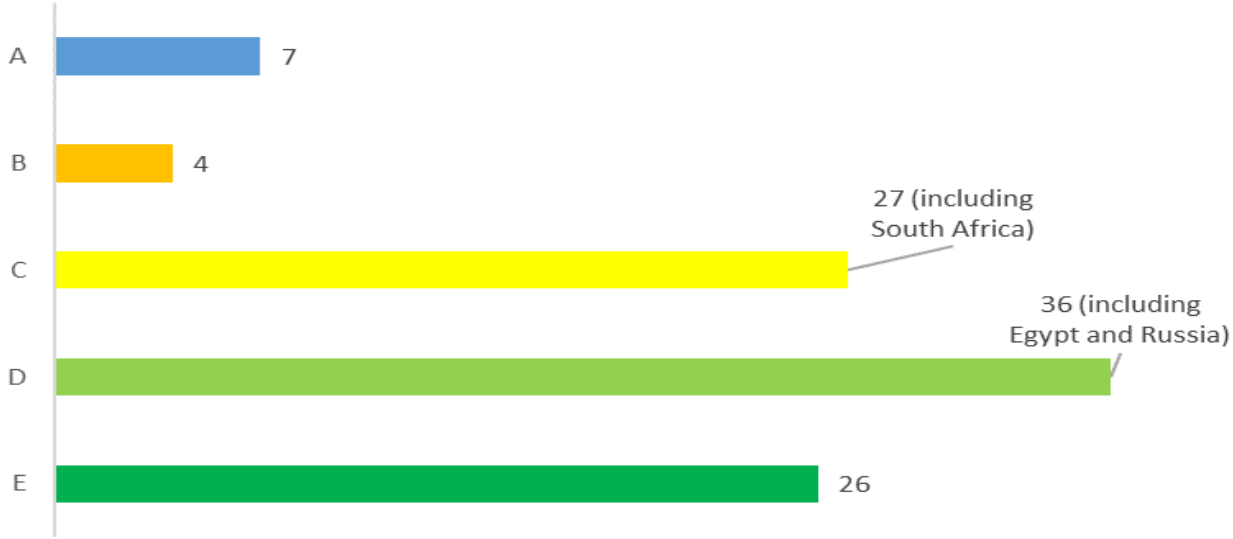


Source: Center for Disease Dynamics, Economics & Policy, [9] *WHO Regional Office for Europe Antimicrobial Medicines Consumption (AMC) Network,*[10] *and the European Centre for Disease Prevention and Control.*[11]

2.3 Progress in developing a national AMR strategy

Nearly all European, Middle Eastern and African countries now have an AMR national action plan implemented or under development. However, there is much that remains to be done; only 29% (26/90) of European, Middle Eastern, and African countries have a national AMR action plan which has funding sources identified, is being implemented, and has relevant sectors involved with a defined monitoring and evaluation process in place (Figure 4). In 2017, the Russian government approved the Strategy to Prevent the Spread of Antimicrobial Resistance in the Russian Federation to 2030.[12] In 2017, Egypt finalised the first phase of a national action plan to combat AMR between 2017 and 2020.[13] In 2014, South Africa published the Antimicrobial Resistance National Strategy Framework 2014-24.[14]

Figure 4: Progress of European, Middle Eastern, and African countries with developing and implementing national action plans on AMR (2019/20)



***A** - No national AMR action plan.*
***B** - National AMR action plan under development,*
***C** - National AMR action plan developed,*
***D** - National AMR action plan approved by government that reflects Global Action Plan objectives, with a budgeted operational plan and monitoring arrangements,*
***E** - National AMR action plan has funding sources identified, is being implemented, and has relevant sectors involved with a defined monitoring and evaluation process in place.*

Source: WHO/OIE/FAO Global Database for Antimicrobial Resistance Country Self-Assessment.[15]

3. Aim

The aim of this project is to apply a previously published AMR governance framework to the AMR national action plans in Egypt, Russia, and South Africa, to identify both strengths and weaknesses in their design, implementation, and monitoring and evaluation. We do not aim to criticize the many well-intentioned and pre-existing efforts to tackle AMR in each country, but instead aim to stimulate discussion regarding how policies to tackle AMR can be strengthened to ensure sustained action. We acknowledge the differences of their healthcare systems design and priorities, varied epidemiology landscape, and economic situation in each country, and any comparisons between countries must be interpreted with this in mind. However, we still strived to identify a number of select recommendations for improvements for each country.

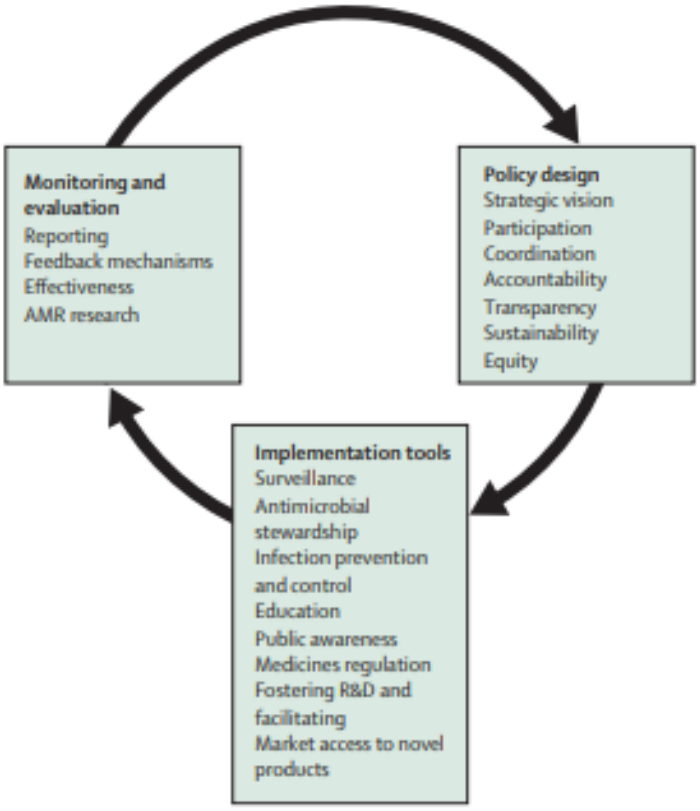
4. Methods

4.1 The AMR governance framework

The LSE, in conjunction with colleagues from ECDC have developed a governance framework to offer guidance for both the development and assessment of national action plans on AMR (Figure 5). The development of the framework involved reviewing health system governance framework reviews to inform the basic structure of our framework. This included international guidance documents from WHO, the Food and Agriculture Organization, the World Organisation for Animal Health, and the European Commission. We also sought the input of 25 experts from international organisations, government ministries, policy institutes, and

academic institutions to develop and refine our framework. The framework consists of 18 domains with 52 indicators that are contained within three governance areas: policy design, implementation tools, and monitoring and evaluation. To consider the dynamic nature of AMR, the framework is conceptualised as a cyclical process, which is responsive to the context and allows for continuous improvement and adaptation of national action plans on AMR.

Figure 5: Antimicrobial resistance governance framework



Source: Anderson et al 2019[16]

4.1.1 *Policy design*

The first governance area (i.e., policy design) is concerned with general and procedural issues of AMR NAPs, such as wide participation in the development of NAPs, coordination across multiple sectors and levels of service delivery (at national and sub-national levels), transparency, sustainability, equity implications of AMR policies, and determining who is ultimately accountable to the government for achieving the objectives of the NAP.

4.1.2 *Implementation tools*

The second governance area (ie, implementation tools) consists of crucial interventions contained within guidance from WHO, the Food and Agriculture Organization, the World Organisation for Animal Health, and the European Commission. Here, three of the domains determine whether surveillance, antimicrobial stewardship programmes, and infection prevention and control measures are implemented across the One Health spectrum. Other domains in this governance area encompass further fundamental AMR tools such as education of relevant professionals, public awareness activities, and medicines regulation. Implementation tools also examine whether appropriate policies and incentives are in place to encourage research and development of novel antimicrobials and alternatives.

4.1.3 *Monitoring and evaluation*

The third governance area (ie, monitoring and evaluation) include reporting and feedback mechanisms that allow for regular review and evaluation of AMR NAPs, and the effectiveness and cost-effectiveness dimensions of different aspects of the NAPs. Finally, the non-therapeutic AMR research domain considers whether a national multidisciplinary One Health research agenda that aims to understand the drivers of and potential strategies to combat AMR exists.

4.2 Application of the framework

Two researchers reviewed publicly available literature relevant to each AMR national action plan, with a focus on the national action plan itself, progress reports, surveillance reports, guidelines, legislation, media reports, and academic literature. This was supplemented by a series of stakeholder interviews with policy-makers, academics, and patient advocacy groups in each country, with representatives across the One-Health spectrum. The full list of stakeholders interviewed is contained within the appendix. The International Alliance of Patient Organizations (IAPO) assisted in the identification and engagement with relevant patient advocacy groups in each country. Collectively, the findings from these processes were used to indicate the achievement or lack thereof for all 52 indicators in the aforementioned AMR Governance Framework for the national action plans in Egypt, Russia, and South Africa. Achievement was classified according to a traffic light system, whereby green indicates that all aspects of the indicator are achieved, yellow indicates some aspects of the indicator are achieved, red indicates that no or very limited aspects of the indicator are achieved. When we have been unable to conclude to what degree an indicator has been achieved the indicator is grey. To justify these findings, we have included a detailed country level analysis in three separate country level reports, and a thematic analysis across policy design, implementation, and monitoring and evaluation in the results. Drawing upon these results, and to stimulate debate, a select number of policy recommendations have been suggested by the co-authors of this report.

4.3 Limitations

The national response to address AMR is a culmination of diverse and collective efforts of many stakeholders across human, animal, and environmental health sectors. Therefore, analysing a national action plan in isolation may not fairly represent the breadth of pre-existing and intended actions taking place in each country, particularly if other actions to tackle AMR are evidenced in other associated documents. To mitigate against this risk, we endeavoured to review a variety of sources of information to inform our analysis including for example the national action plan itself, progress reports, surveillance reports, guidelines, legislation, media reports, and academic literature. However, it is possible that we have overlooked relevant sources of information, particularly as we have been limited by research capacity and, despite securing assistance from Arabic and Russian speakers, language capability. While we do sometimes comment on whether implementation of the stated objectives has taken place or not in each country, the objective of this analysis was not to offer a progress report of the AMR national action plan in each country. Instead, the objective was to offer an assessment of whether the design of each AMR national action plan supported sustainable implementation of the contained policies. Finally, there is an inevitable subjective element to our assessment of each AMR national action plan, and the level of achievement for each relevant indicator in the AMR Governance Framework, and this needs to be borne in mind when interpreting the findings of this analysis.

5. Results

5.1 Policy design

Table 1: Cross-Country Comparison of AMR indicators

		EGYPT	SOUTH AFRICA	RUSSIA
Policy Design				
Strategic Vision	Has a situational analysis been conducted to determine the prevalence and incidence of AMR organisms in the country?			
	Is a national action plan (NAP) in place, if not what is the timeframe for developing and implementing the NAP			
	Are the objectives contained within the NAP specific, measurable and time-bound?			
	Are there quantitative targets for AMR/antimicrobial use outlined in the NAP?			
Coordination	Is coordination between sectors and across different levels of each sector considered?			
	Is there a ministry and/or intersectoral committee responsible for coordination and implementation?			
Participation	Was a high level of stakeholder participation facilitated throughout the development of the NAP?			
	Are the activities in the NAP inclusive across all 'One Health'-related sectors? If so, how, and if not, why not?			
	Was there support from a technical advisory group or subject matter experts during development of the NAP?			
Accountability	Is there an ministry and/or intersectoral committee responsible for coordination and implementation which is accountable to the Government?			
	Is a responsible person nominated in each sector and do agreements exist regarding what happens if objectives are not met?			
Transparency	Is the complete NAP publicly available?			
	Are all progress reports publicly available?			
	Is all funding information publicly available?			
	Is all AMR/antimicrobial use surveillance data publicly available ?			
Sustainability	Is there either a written mandate or voluntary agreement from all relevant sectors in place to implement the NAP?			
	Are there dedicated budgets in place to implement specific activities in the NAP?			
	Is there an assessment of future budget requirements for different activities listed in the NAP?			
	Is there ongoing support from a technical advisory group or subject matter experts during implementation, monitoring and evaluation of the NAP?			
Equity	Does the NAP include both encouraging responsible use and facilitating equitable access to existing essential antimicrobials?			

** Green = achieved all aspects of the indicator, yellow = achieved some aspects of the indicator, red = did not achieve any aspect of the indicator. Grey: Unable to establish throughout our research*

5.1.1 *Strategic vision*

All three countries have NAPs in place, which specify strategic objectives and timelines for their implementation. Egypt's NAP is titled "*The Arab Republic of Egypt National Action Plan For Antimicrobial Resistance (2018-2022)*",[17] South Africa's NAP is titled '*The South African Antimicrobial Resistance National Strategy Framework; A One Health Approach 2018 – 2024'* ,[18] and Russia's NAP is titled '*Strategy for preventing the spread of antimicrobial resistance in the Russian Federation for the period up to 2030'*.[19] Quantitative targets are specified in Egypt's NAP and include five targets by 2022 for human, animal and environmental health. Neither Russia's, nor South Africa's NAP outlines quantitative targets for antimicrobial usages or resistance rates. However, the Russian NAP includes a quantitative target for the retraining of 20% doctors responsible for prescribing antimicrobials by 2020, and 100% by 2030. Russia has an implementation strategy to cover the period 2019-2024.[20] South Africa has two implementation plans: *"Implementation Plan for the Antimicrobial Resistance Strategy Framework in South Africa: 2014–2019",*[21] and *''Guidelines on the implementation of the antimicrobial strategy in South Africa: One Health Approach & Governance June 2017'*.[22]

South Africa conducted a situational analysis focusing primarily on human health, which is outlined in country's NAP*,* Antimicrobial Resistance Background Document',[23] and *The AMR Background Report and* Situation *Analysis; Antibiotic use and resistance in South Africa*'.[24] Neither Russia's nor Egypt's NAP includes a formal situational analysis, however, Egypt's NAP refers to studies which have profiled the rate of resistant bacteria in Egyptian hospitals.[25–32]

5.1.2 *Participation*

Stakeholder participation was facilitated in Egypt throughout the development of the NAP, such as by hosting multi-sectoral meetings with over 50 national experts from the diverse fields including representatives from the Ministry of Health, Ministry of Agriculture, Ministry of Environment, World Health Organisation and the Food and Agriculture Organisation (FAO). To what degree the public or patient advocacy groups were consulted in the process is unclear, although select non-governmental groups we interviewed indicated that opportunities to participate in the process of health policy development are limited. The actions listed in the Egyptian NAP are across the 'One-Health' spectrum, including human, animal and environmental health.

The South African and Russian NAPs do not specify the level of stakeholder participation during the development process, although our interviews revealed that stakeholders were involved across the 'One-Health' spectrum. The South African NAP considers activities across all 'One-Health' sectors, including human health, animal health and ecosystems. Russia's NAP also addresses the 'One-Health' perspective, including objectives and actions across human and animal health, however, environmental health receives less attention.

Egypt's NAP outlines plans for a series of technical working groups to oversee policy implementation, although interviews revealed that in practice this is not happening currently. The Ministry of Health in Russia created a technical advisory group on Clinical Microbiology and Antimicrobial Resistance, however, no equivalent seems to be available for animal or environmental health.[33] South Africa did not explicitly outline whether a technical advisory or expert group was involved in the NAP development, but an AMR intersectoral ministerial committee has been subsequently established.

5.1.3 *Coordination*

The Egyptian NAP considers coordination between sectors, and within human health for different levels of the health system, such as establishing antimicrobial stewardship programmes in both primary health centres and hospitals. Less emphasis is placed on coordination within the animal and environmental health sectors. South

Africa's NAP outlines objectives for coordination between the human, animal and environmental sectors and across provincial, district and local levels. Veterinary services, environment, sanitation and water departments are considered, as are district hospital, community and primary healthcare clinics. The Russian NAP emphasises the importance of ensuring interagency cooperation between human, animal, and environmental health. However, coordination across the different sector levels receives less consideration.

All three countries have a body that is responsible for the NAP's coordination and implementation. The Egyptian National Focal Point is located within the Ministry of Health. The plan outlines how the Ministry of Health intended to convene a national AMR committee consisting of four technical working groups with representation across the 'One-Health' spectrum, although interviews revealed this has not happened in practice. South Africa established an interdisciplinary National Advisory Committee (MAC-AMR), with representation from the relevant government departments, the public and private sectors, academia and universities, relevant clinical societies and other related groups. Russia's NAP does not mention a responsible body. However, stakeholder interviews revealed the existence of a ministerial committee called the "Intersectoral Committee for Prophylaxis of New Infections and AMR". Annual intersectoral roundtables have further been reported in Russia, which aim to share experiences and coordinate actions between sectors. [34]

5.1.4 *Accountability*

The NAPs of Egypt, South Africa and Russia outline the existence of a committee responsible for coordination and implementation that is accountable to the government. The Egyptian NAP states that, once established, the national AMR committee is to be directly under the supervision of the Ministry of Health. South Africa established a multi-disciplinary intersectoral Ministerial Advisory Committee on AMR (MAC-AMR), which reports to the Minister of Health within the National Department of Health. In Russia, the ministerial committee called the "Intersectoral Committee for Prophylaxis of New Infections and AMR" is accountable to the government, as well as the ministries listed within Russia's NAP.

Egypt's national AMR committee was intended to be chaired by the Minister of Health. However, the NAP does not state who is responsible for taking actions within each sector and no clear agreements exist regarding procedures when objectives are not met. South Africa's NAP does not list responsible persons, although

responsible directorates and heads of departments regarding different objectives across sectors are named in the country's implementation plans. Both South Africa's NAP and the implementation plans do not outline agreements if the objectives are not met. Russia's 2019 to 2024 implementation plan assigns responsibility for coordination and implementation to designated ministries, agencies, and not-for-profit organisations. The Ministry of Agriculture, and the Federal Service for Veterinary and Phytosanitary Surveillance (Rosselkhoznadzor) are responsible for animal health. Stakeholder interviews revealed that deputy ministers are typically responsible for implementing the actions assigned to the respective ministry. The implementation plan does not outline any agreements if objectives are not met.

5.1.5 *Transparency*

The South African and Russian NAP are both publicly available. While Egypt's NAP is available on the WHO website, it is not widely available in Egypt or widely disseminated. Stakeholders interviewed were either unable to obtain a copy of the Egyptian NAP, or had to request the NAP from the Ministry of Health. As of 2020, neither Egypt or Russia has published progress reports for the NAP. South Africa made one surveillance report publicly available dated 2018, which details the situation in South Africa over the period 2012-2017.[35] Future plans for surveillance are also included. Stakeholders interviewed also made reference to a progress report published prior to the Covid-19 pandemic, although we were unable to find an easily accessible public version.

Regarding the funding earmarked for the implementation of activities listed in the NAP, Russia does not provide publicly available information. South Africa mentions funding in the published documents, yet the funding is not quantified and no sources of funding are identified. The Egyptian NAP outlines a budget for the activities

outlined under each objective. This budget is an estimation, with no detailed costing of activities described. There is also no budget impact assessment or clear plan where funding will be raised from. Instead, the Egyptian NAP mentions that an additional technical working group will be formed with the task of fund raising.

AMR surveillance data is not publicly available in Egypt, with the exception of some academic publications,[26,30] and the WHO Global Antimicrobial Resistance Surveillance System (GLASS). In South Africa, several publicly available sources on AMR surveillance are available, including a national surveillance dashboard. Russia has a publicly available online repository of AMR surveillance data, called AMRmap.[36] In addition, several multicentre studies have been published in academic journals,[37,38] but policy makers and the public would find these difficult to interpret.

5.1.6 *Sustainability*

A written mandate for NAP implementation exists from all relevant sectors in Egypt, South Africa and Russia. The Egyptian NAP nominates the relevant ministries, e.g. Ministry of Health, Ministry of Agriculture, and Ministry of Environment, to be responsible for the implementation with a mandate to implement actions within their own sectors. In South Africa, all relevant sectors are represented on the MAC-AMR, which has been mandated to implement the NAP. Russia's NAP itself is an order of the Government of the Russian Federation. This provides stakeholders with the mandate to implement the associated actions. However, there are no specific agreements from all relevant sectors to implement the NAP.

None of the three countries has dedicated budgets in place to implement specific activities in the NAP. The Egyptian NAP mentions an additional technical working group tasked with fundraising. In Russia, the ministries are responsible for requesting additional funding. Alternatively, financial support for NAP activities should be allocated from pre-existing budgetary allocations for corresponding federal executive authorities. Assessments of future budget requirements for different activities listed in the NAP are not included in any of the NAPs.

Ongoing support was intended to be provided by four separate technical working groups in Egypt, although stakeholder interviews revealed that this has not happened in practice. In South Africa, the MAC-AMR provides a forum where subject matter experts can advise policy-makers in various ministries. The committee consists of a broad membership across human, animal, and environmental health. In Russia, the technical advisory group on Clinical Microbiology and Antimicrobial Resistance,[33] led by Dr Roman Kozlov, provides guidance for policies and interventions aligned to the Russian NAP. There does not appear to be an equivalent from the animal health sector.

5.1.7 *Equity*

The Egyptian NAP mentions how an objective of National One-Health Surveillance should be to ensure access to prevention and treatment of infections, especially in resource-poor settings. Apart from this, there is no other mention of equity of access to essential antimicrobials within the Egyptian NAP. Facilitating equitable access is mentioned in "*Sub-objective 5.1: Ensure access to safe, effective and affordable antimicrobials.",* in the South African NAP. This section briefly addresses equity of access, but not in great detail. Despite the Russian AMR Strategy emphasizing the importance of new antimicrobials development, the Russian NAP does not outline measures facilitating affordability and ensuring access to antimicrobials. However, equity is considered in some policies, for example fair and equal access to antimicrobials in Russia contained within an Essential Drugs List, which contains medications expected to be made available to all citizens.

5.2 Implementation tools

Table 2: Cross-Country Comparison of AMR indicators

		EGYPT	SOUTH AFRICA	RUSSIA
Implementation Tools				
Surveillance	Is there a national surveillance system for resistant organisms across the human, animal, and the environmental health sectors?			
	Is there a national surveillance system for levels of antimicrobial use in animals and humans?			
	Is there adequate laboratory capacity and capability supported by regular external quality assessments?			
Antimicrobial Stewardship	Are there stewardship programmes across human and animal health sectors?			
	Are rapid diagnostic tools widely available and in regularly use? if so, do national guidelines regarding their indication and interpretation exist?			
	Are there up-to-date national guidelines on antimicrobial use across a wide range of settings in animal and human health?			
	Is there any use of financial and non-financial incentives/penalties in animal and human health to reduce inappropriate use of antibiotics?			
Infection prevention and control	Are there IPC policies across all levels of human, animal and environmental health sectors?			
	Are there up-to-date national guidelines for IPC across human, animal and environmental health sectors?			
	Are immunisation programmes utilised as an approach to prevent infections across human and animal health sectors?			
	Are financial and non-financial incentives/penalties for IPC policies utilised across human, animal and environmental health?			
Education	Is there certifications or programmes in place to ensure a basic education for all involved groups of professionals to deliver necessary understanding for strategies to tackle AMR?			
	Is there continuing education programmes for all involved groups of professionals to ensure expertise necessary for expanding knowledge and sustained efforts to tackle AMR?			
	Is there a workforce strategy which aims to deliver the sustainable supply of the necessary workforce required to deliver antimicrobial stewardship and IPC policies?			
Public Awareness	Are there multi-modal public awareness campaigns that focus on AMR and educational programmes (including school children) related to AMR?			
	Do the implemented public awareness campaigns have an ongoing character?			
	Does the conception of the public awareness campaign consider aspects of behavioural sciences, social science and psychology?			

Medicines Regulation	Are there regulations in place to ensure appropriate use of antimicrobials in human health?			
	Are there regulations in place to ensure appropriate use of antimicrobials in animal health?			
	Is there an authority in place to monitor and enforce legislation, if so does this authority have a dedicated budget?			
Fostering R&D of Antimicrobials or Alternatives	Is fostering R&D and facilitating market access to novel antimicrobials, diagnostics, vaccines and alternative treatments in both human and animal health listed as a priority in NAP?			
	Does the NAP consider how the country can contribute to R&D of novel agents at both a national and international level?			
	Is there a dedicated national budget for R&D of novel antimicrobials, diagnostics, vaccines, or alternative treatments?			

Green = achieved all aspects of the indicator, yellow = achieved some aspects of the indicator, red = did not achieve any aspect of the indicator. Grey: Unable to establish throughout our research

5.2.1 *Surveillance*

The Egyptian NAP mentions the existence of a national healthcare-associated infection surveillance programme since 2011. This system is supported by a Central Public Health Laboratory, which undertakes antimicrobial susceptibility testing. However, within the surveillance system important gaps exist. The private sector, which provides 25-30% of health care in Egypt, does not report data to the central laboratory. Further, several academic studies describe multi-drug resistant pathogens in poultry,[39,40] and evidence that meat purchased at markets is responsible for subsequent infections in humans.[41,42] Yet, the Egyptian NAP acknowledges that data and trends on prevalence of drug resistance in animal health are sparse. To address this, the Egyptian NAP includes the goals of having a nationwide AMR surveillance system for the human and animal health sectors as well as a national early warning system in place by 2020. It has not been clear from our interviews whether this has been achieved, or whether actions have taken place to achieve this goal.

The South African NAP outlines a clear action plan until 2024 for surveillance of AMR to be gradually rolled out across provinces and across sectors including humans, animals and the environment. A national surveillance report published in 2018 reports surveillance data for both the human and animal sectors. Additionally, for the human sector, there is a national surveillance dashboard, which reports data for regions, organisms and antimicrobials. It is unclear whether a surveillance system for the environmental health sector exists.

In Russia, there is an online repository on multicentre AMR surveillance called AMRmap,[36] a repository of genetic variations of resistant bacteria,[43] as well as an online repository of AMR surveillance data for both human and animal health, the AMRcloud online.[44] In addition, antimicrobial residues in raw food materials and food products are routinely monitored. No surveillance system is available for environmental health, but there is ongoing scientific research.[45] Russia's NAP, the 2019-2024 implementation plan and Action Plan to implement the *Russian Federation Framework for Chemical and Biological Safety Through 2025 and Beyond* outline the establishment of an integrated, interagency surveillance system.[46] This includes surveillance of AMR in food raw materials, food products, agricultural crops, and animal waste.

Regarding antimicrobial use in animals and humans, systematic surveillance systems do not exist in Egypt. The Egyptian NAP outlines objectives to establish a national surveillance system for both the human and animal sectors, and publish annual antimicrobial use reports. So far, only examples of point prevalence surveys of antibiotic use in hospitals are available.[30] In Russia, there is a continuous AMR survey that includes >30

hospitals in different regions of Russia, that has existed since 2012. Russia's 2019 to 2024 implementation plan includes an action to develop a surveillance system for the use of antimicrobials in both human and animal health by end of 2021. Data regarding antimicrobial use is available for hospitals,[37,38] but not the primary care sector, which has been attributed to a lack of health information technology and electronic record infrastructure.[47] South Africa's 2017 implementation plan tasked the MAC-AMR with implementing national surveillance and reporting systems for antimicrobial use in humans and animals. Figures for use in humans and animals are reported in the 2018 surveillance report.[35] The South African Animal Health Association also appears to collect data, however, it is unclear how this can be accessed.

Surveillance requires adequate laboratory capacity and capability supported by regular external quality assessments. The Egyptian NAP includes the objective to "implement a lab quality management system in all laboratories".[17] It acknowledges that current laboratory capacity and capabilities are insufficient, including frequent noncompliance of guidelines for microbiological processing, weak enforcement of national regulation for laboratory licensing and insufficient governmental supervision of private laboratories. South Africa's NAP identifies the importance of laboratory capacity, timely microbiological data, good quality management systems and consistent diagnostic standards. The participation of the National Health Laboratory Service and private laboratories (including those serving the veterinary sector) is mentioned. It is unclear whether regular external quality assessments are taking place in Egypt or South Africa. Russia's 2019 to 2024 implementation plan includes actions to improve laboratory facilities and develop and implement uniform standards for laboratories. Regular guidance on the necessary requirements for surveillance and methodological support to laboratories are published.[48] For laboratories in Russia it is recommended (not mandatory) to participate in the external quality assurance program of the "Centre of External Quality Assurance".[49]

5.2.2 *Antimicrobial stewardship*

The Egyptian NAP contains the goal to develop and implement national antibiotic stewardship programmes in both human and animal health. So far, the use of stewardship programmes is sporadic in human health,[50] and lacking in animal health. South Africa's NAP and the 2017 implementation plan outline objectives and detailed plans for antimicrobial stewardship across human and animal health.[22] Guidance on antimicrobial stewardship in South African hospitals is provided in '*Guidelines for the prevention and containment of Antimicrobial Resistance in South African hospitals'*.[51] In Russia, examples of hospital stewardship programmes,[52] as well as national guidance for implementation of antimicrobial stewardship programmes are mentioned in academic literature.[53,54] Stewardship programmes do exist in the animal health sector, for example those run by the Advisory Center on the Development and Transfer of System Technologies in Veterinary Medicine and Agriculture, which works with local regions and industry to develop antibiotic free meat products.[55] Although, these programmes are developed independently of government, and stakeholders interviewed felt they required more governmental support to facilitate wider implementation.

The use and availability of rapid diagnostic tools is unclear across Egypt and South Africa, with some exceptions such as urine dipsticks and pneumococcal antigen tests. Whereas in Russia, stakeholder interviews revealed there is a growing number of laboratories that use rapid diagnostic tools such as polymerase chain reaction (PCR) for the detection of resistant pathogens. The Egyptian and South African NAPs include objectives to address this. South Africa's 2017 Implementation Plan further assigned responsibility to the MAC-AMR for ensuring access to appropriate diagnostic tests and national guidance on their appropriate use.

The Egyptian NAP acknowledges that national guidelines on antimicrobial use and rapid diagnostic tools do not exist in the human or animal sector. However, objectives for their development are outlined. In South Africa, antimicrobial prescribing in the public sector is guided by the Standard Treatment Guidelines and Essential Medicines List for South Africa.[56] In addition, a pocket guide to antibiotic prescribing for adults in South Africa was developed in 2015, which is reportedly widely used.[57] There do not seem to be national guidelines for the animal health sector. Russia has several regularly updated national guidelines for human health available online.[53,54,58,59] For animal health, no recent national guidelines seem to be available, however,

the 2019-2024 implementation plan includes an action to develop guidelines for the animal health sector By end of 2021. [20]

There are no financial and non-financial incentives or penalties for reducing inappropriate use of antibiotics in human and animal health in Egypt or South Africa. In contrast, the Egyptian NAP acknowledges that the pharmaceutical industry has a negative influence on prescribing habits. Russia does not appear to use financial incentives or penalties in human health. In animal health financial penalties are intended to enforce a ban on the use of antimicrobials for non-therapeutic purposes.

5.2.3 *Infection prevention and control*

The Egyptian NAP acknowledges that infection prevention and control (IPC) policies are inconsistent and improperly implemented across the human health, animal health and environmental health sectors. National guidelines for IPC in human health exist, but the latest available are dated from 2005 and it is unclear how frequently these guidelines are updated.[60,61] No national standardised guidelines are available for the animal and environmental health sectors. South Africa's NAP identifies enhancing IPC as a key strategic objective, and detailed IPC strategies and implementation plans are outlined in several recently updated guidelines. [51,62,63] In Russia, national IPC policies are available and predate the NAP, such as the "National Concept of Prevention of Health Care Associated Infections" (2011),[64] and there are guidelines for IPC in human health,[65] and animal health.[66] For environmental health, gaps in the Russian legislation for medical and pharmaceutical waste management have been highlighted as barrier to developing a coherent IPC strategy.[67,68] There was consensus among stakeholders interviewed that infection prevention control practices had improved during the Covid-19 pandemic, and they expected this to continue post pandemic.

In Egypt, vaccination coverage for children has improved. However, there is no comprehensive immunisation programme for adults or animals; objectives for both are outlined in the NAP. South Africa identifies immunisation as a key tool in IPC. The country has a human immunisation programme,[69] and guidance for immunisation in animals is provided.[70–73] Russia has a well-developed immunisation programme with high levels of coverage in human health.[74] Additionally, it has an immunisation programme for IPC in animal health.[75,76]

None of the three countries uses financial or non-financial incentives for IPC policies across human, animal or environmental health.

5.2.4 *Education*

Basic education for professionals to address AMR are inconsistently available in Egypt, South Africa and Russia. The Egyptian NAP aims to incorporate AMR and the Antibiotic Stewardship Programme in the professional training for health and veterinary professionals and at agriculture faculties. Continuing education programmes for healthcare professionals are available.[77] While none could be found for animal health, their development is mentioned in the Egyptian NAP. South Africa's NAP recommends to incorporate education and training in tackling AMR into the training of human and animal health professionals. Additionally, implementation guidelines are available and outline a variety of training courses.[51,63] The Russian 2019-2024 implementation plan specifies actions to include AMR in educational programmes for human and animal health professionals. Continuing educational programmes for healthcare professionals in human health are available,[78] whereas none could be found for animal health. Stakeholders interviewed felt that for strengthened regulation of antimicrobials in animal health to be effective there needed to be increased investment in education of relevant animal health professionals.

Egypt and Russia do not have a workforce strategy to ensure a sustainable supply of the necessary workforce to deliver AMR stewardship and IPC policies. The Egyptian NAP lists the limited availability of infectious disease specialists as barrier in the country's AMR response. Russia recently introduced medical microbiology as a formal and accredited speciality.[79] South Africa's NAP implementation plan 2014-2019 mentions

workforce plans, particularly addressing AMR stewardship and IPC practitioners, while the NAP mentions the need for animal health technicians in rural areas.

5.2.5 *Public awareness*

Egypt piloted a successful awareness campaign in 2011, however, this was not translated into a national campaign.[80] Several barriers for public awareness campaigns are cited in the NAP, including inadequate financial resources and inconsistent leadership commitment. To address this gap, the NAP outlines objectives for school education and national awareness programmes. South Africa's NAP and implementation plans propose public awareness campaigns for AMR, and also mention an annual World Antibiotic Awareness Week campaign. With the exception of a hand hygiene strategy for the period 2016-2020,[81] no evidence of other awareness campaigns could be found. Russia is the only country that has developed a public awareness campaign.[82] The continuation and expansion of the campaign is mentioned in the 2019-2024 implementation plan.

It does not appear that any of the three countries consider aspects of behavioural sciences, social science or psychology for the conception of their public awareness campaigns.

5.2.6 *Medicines regulation*

The Egyptian NAP highlights a lack of legislation and regulation concerning antimicrobial use in human and animal health as a major barrier to strengthening the Egyptian response to AMR. Antimicrobials are frequently purchased without a prescription in human health,[83] and used for non-therapeutic purposes in the animal sector. Stakeholder interviews also revealed that direct to consumer advertisement is commonplace. A review of the current legislation for regulating antimicrobial prescribing and dispensing practices is proposed in the NAP, but our stakeholder interviews indicated that this has not yet happened. The National Drugs Regulatory Authority is responsible for regulation and market authorization of drugs. However, effective regulation of antimicrobials remains limited, and is further constrained by the lack of a national surveillance system.

In South Africa, antimicrobials require prescription and are not legally available over the counter. For animal health, a limited number of antimicrobials are available over the counter (largely to benefit farmers living in rural areas), whilst other legislation requires prescription. This dual system creates concerns regarding appropriate regulatory oversight, with the National Veterinary Strategy 2016-2026 advocating for a single act.[84–86] The South African Health Products Regulatory Authority (SAHPRA),[87] was established in 2018 to monitor and enforce legislation in animal and human health.

In Russia, over the counter sales of antimicrobials for human health are banned. Despite, this, the ban is sometimes not enforced,[88] and self-medication by pharmacists is common.[89] The NAP and 2019-2014 implementation plan outline actions to strengthen regulation, including a ban on advertisement and illegal import. In 2019, the use of non-therapeutic antimicrobials in animals were banned, and prescribers are now required to clearly document the indication of use.[90] Additionally, decisions by the Eurasian Economic Commission (EEC) have an impact on the use of antimicrobials in animal health.[91–93] For human health, the Federal Service for Surveillance in Healthcare (Roszdravnadzor) is the authority in place, while for animal health the Federal Service for Veterinary and Phytosanitary Surveillance (Rosselkhoznadzor), and the Russian State Center for Quality and Standardization of Veterinary Drugs and Feed (VGNKI) are tasked with monitoring and enforcing legislation.[94]

5.2.7 *Fostering R&D*

The Egyptian NAP includes finding novel therapies in the mission statement, but there are no concrete actions related to fostering R&D at national or international level, or for facilitating market access to novel agents. There is also no evidence of a dedicated national budget for antimicrobial R&D. South Africa's NAP outlines objectives for R&D into novel diagnostics and therapeutics. In 2019, the South Africa-UK AMR Drug Discovery Partnership Hub Initiative was launched, which is funded by the UK Medical Research Council (MRC) and

South Africa Medical Research Council (SAMRC).[95] Russia declares R&D of novel antimicrobials, diagnostics, vaccines and alternative treatments a priority in the NAP, and has invested in developing bacteriophages, an alternative to antibiotics that was used commonly in Soviet-era Russia.[96] International research cooperation is mentioned and taking place, for instance between the UK AMR Centre and the Skolkovo Foundation in Russia.[97] Despite this, there does not seem to be a dedicated national budget for antimicrobial R&D.

5.3 Monitoring and evaluation

Table 3: Cross-Country Comparison of AMR indicators

		EGYPT	SOUTH AFRICA	RUSSIA
Monitoring and Evaluation				
Reporting	Are annual AMR NAP 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 transmission to international surveillance systems?			
Feedback mechanisms	Are there feedback mechanisms in place which relay surveillance data back at both regional and organisational level?			
	Are there regular deadlines in place to review progress of specific actions within the NAP, and arrangements to feedback at both regional and organisation level?			
Effectiveness	Have there been efforts to evaluate the effectiveness (e.g. measure of impact on human and animal health) of specific policies and/or interventions implemented?			
	Have there been efforts to evaluate the cost-effectiveness (e.g. measure of impact on human and animal health) of specific policies and/or interventions implemented?			
AMR Research	Is research to understand both the drivers and impact of AMR as well as potential policies and interventions identified as a key priority in the NAP?			
	Is there a dedicated national budget for AMR research in place?			

[l] *Green = achieved all aspects of the indicator, yellow = achieved some aspects of the indicator, red = did not achieve any aspect of the indicator. Grey: Unable to establish throughout our research*

5.3.1 *Reporting*

As of 2020, neither Egypt or Russia have published any AMR NAP progress reports or surveillance reports containing data regarding the incidence of resistant organisms and antimicrobial use. Stakeholders in Russia felt that an annual surveillance reports are not necessary, as publicly data from platforms such as AMRmap, can be freely accessed and visualised to provide updates on progress. South Africa published a surveillance report in 2018.[35] This document includes resistance data for the public and private sectors, antimicrobial use in the human and animal sectors and antimicrobial residues from the national chemical residues monitoring

program in animal health. All three countries collaborate with the WHO Global Antimicrobial Resistance Surveillance System (GLASS).[98]

5.3.2 *Feedback mechanisms*

While the Egyptian National Antimicrobial Stewardship Program includes objectives to provide hospital level surveillance reports,[99] the degree to which feedback mechanisms consistently relay AMR surveillance data at regional or organisational level is not clear. Stakeholders interviewed revealed that in practice, AMR or AMU data is rarely feedback at organisational level. The South African 2017 implementation plan mandates feedback mechanisms between hospital and provincial antimicrobial surveillance committees, and the nationwide network of clinical microbiology laboratories. Prospective audits to monitor compliance are also outlined, with feedback to prescribers. In Russia, the publicly available platform AMRmap provides a visualities of surveillance data.[36] However, it is not clear to what extent formal feedback mechanisms are in place, or whether hospitals are expected to review and act on their own data.

All the NAPs include regular deadlines for outlined objectives, although the extent to which these deadlines are reviewed and individuals held accountable is not clear. In the Egyptian NAP, each high-level objective has a monitoring and evaluation plan, which details a quantitative target, and a commitment regarding how frequently this will be measured. Although in practice, stakeholder interviews revealed that this is not routinely happening. South Africa's NAP includes a table specifying timeframes for achievement of the activities related to the strategic objectives. However, progress in achieving these are not discussed within the 2018 surveillance report, [35] and during our research we have been unable to identify any progress reports. Russia's NAP has an accompanying implementation plan which contains 14 key actions, and associated sub actions intended to be implemented between 2019 to 2024.[20] For each of these actions there is a responsible ministry and deadline for achievement, but there are no progress reports. It has therefore been challenging to ascertain to what degree these deadlines are being reviewed or what feedback is provided to the ministries.

5.3.3 *Effectiveness*

There appears to be piecemeal efforts in Egypt, South Africa or Russia to evaluate the effectiveness of various policies and interventions to tackle AMR. Evaluations have been published in several academic studies. For instance, in Egypt a pilot awareness campaign,[80] and antimicrobial stewardship programmes,[50] were evaluated. Yet, despite the Egyptian NAP mentioning research on the economic impact of AMR and its interventions as a priority, there have been no efforts to evaluate the cost-effectiveness of specific policies or interventions. In South Africa, multiple studies have been published,[100–102] including evaluations of the cost-effectiveness of specific policies or interventions.[103,104] Additionally, a review of the NAP implementation in different institutions and regions has been performed,[105] which provides a reflection on some of the key challenges. Similarly in Russia, several examples of academic publications which monitor effectiveness of policies are available,[52,106–109] but there is no evidence that cost-effectiveness studies have been conducted.

5.3.4 *AMR research*

Strengthening the knowledge and evidence base of both the drivers and impact of AMR is a key strategic objective listed within the Egyptian NAP. Similarly, the South African NAP lists a number of priority research areas and operational research needs. It also recognises delays in access to new products as a particular problem, with research aiming to support the preservation of current antimicrobials. Russia's NAP and 2019-2024 implementation plan also include research as a key objective and outlines actions to develop a comprehensive research plan to study mechanisms of AMR as well as preventative strategies. Despite commitments to AMR research from all three countries, none has a dedicated national budget in place to fund these activities.

6. Recommendations

The following outlines recommendations for stakeholders in Egypt, South Africa, and Russia to consider across the domains of policy design, implementation, and monitoring and evaluation in relation to their AMR NAPs. The recommendations are classified according to those which should be prioritised in the short-term over the next two years and medium term over a longer period. The specific actions required to achieve these recommendations can be elaborated on further within future NAPs. We do not intend these recommendations to be comprehensive, instead we hope to outline a select few recommendations which reflect major gaps in governance identified during our analysis and stakeholder interviews. While some of the recommendations are similar between countries, others are different and reflect how each country is at different stages of developing national strategies to respond to AMR.

6.1 Policy design

6.1.1 *Egypt*

Short-Term

- For high-level political leadership in Egypt to acknowledge that the 2018-22 Egyptian NAP was not widely disseminated or followed by sustained action, and to encourage open debate through a public inquiry to identify the potential underlying factors why this has happened.

- To nominate responsible individuals for overseeing implementation of the Egyptian NAP within the Ministry of Health as the National Focal Point, and the four associated technical working groups aligned to the four objectives of the Egyptian NAP.

- By end of 2021, to have allocated earmarked funding to facilitate at least quarterly meetings of the technical working groups aligned to the four objectives of the Egyptian NAP. For the membership of each technical working group to include representatives across the One Health spectrum, and patient advocacy groups.

- By 2022, to have published a revised version of the Egyptian NAP with revised timelines that reflect progress or lack of progress during the Covid-19 pandemic with broad involvement of civil society, in a widely accessible public domain to ensure that all relevant stakeholders can review, scrutinise, and engage with its stated objectives, actions, and deadlines.

6.1.2 *South Africa*

Short-Term

- For high-level political leadership in SA to commit to sustainable action to tackle AMR as a major priority in the post Covid-19 recovery phase. This should include renewed emphasis on a balanced One Health approach to ensure that human, animal and environmental health are given equal priority, as well as facilitating mechanisms for involvement of civil society in the development, implementation, and monitoring and evaluation of policy.

- To develop a detailed budget impact assessment for activities contained within the SA AMR national action plan as well as allocating dedicated funding to implement contained activities

- To design and implement accountability mechanisms at every level; national, provincial, organisational, and individual, in terms of both antimicrobial stewardship and infection prevention control. This should be facilitated by developing a fully integrated One-Health surveillance system

across human and agricultural sectors for both AMR and AMU to allow for monitoring, feedback and accountability.

6.1.3 *Russia*

Short-Term

- For high-level political leadership to ensure that tackling AMR remains high on the political agenda, progress in implementing the NAP is frequently reviewed, and responsible ministries held accountable.
- To consider the use of national and/or regional quantitative targets for AMR and antimicrobial usage as a mechanism for benchmarking and to improve engagement around a common purpose, and allow transparent monitoring and evaluation of the Russian NAP.
- To facilitate the involvement of patient advocacy groups and broader civil society in the development, implementation, and monitoring and evaluation of the Russian AMR national action plan.
- To conduct a budget impact assessment of activities contained within the NAP followed by allocating dedicated funding to the governmental organisations/ministries responsible for the implementation.

6.2 Implementation tools

6.2.1 *Egypt*

Short-Term

- By end of 2021, for Egypt to have launched a consultation with stakeholders across the human health sector including patients, physicians, pharmacists, and the pharmaceutical industry on proposed legislation to ban access to antimicrobials without a prescription
- By end of 2021, for Egypt to have launched a consultation with stakeholders across veterinary medicines and the agricultural sector on proposed legislation to ban the use of antimicrobials for non-therapeutic purposes in animal and plant health.
- By 2022, to have launched a nationwide multimodal public awareness campaign on the issue of AMR, including the importance of antimicrobial stewardship and infection control
- By 2022, to have launched a nationwide educational programme for physicians and community pharmacists in antimicrobial stewardship including limiting the use of over the counter antimicrobials and encouraging alternative treatments.
- By 2022, to have developed a workforce strategy to recruit, train and retain the necessary personnel to implement the NAP, including a sufficient number of seminarians, infection control nurses, and infectious disease specialists.
- By 2022 to have undertaken a budget impact assessment of the necessary funds required to strengthen surveillance and laboratory capacity to the extent whereby annual surveillance reports can be produced with reliable estimates of AMR rates at national, regional, and organisational level. This should be followed by earmarked funding allocated to the Ministry of Health for the purposes of achieving this goal.

Medium-Term

- By 2023, for Egypt to have passed legislation that bans the non-therapeutic use of antimicrobials in animal health, and introduces the requirement for a prescription by a veterinarian for access to antimicrobials

- By 2024, for Egypt to have passed legislation that bans access to antimicrobials without a prescription in human health, as well as the introduction of penalties and enhanced regulation of the community pharmacy sector.

- In parallel with efforts to expand universal health coverage in Egypt, to expand capacity in primary care, in a manner that increases collaboration between primary care physicians and community pharmacists to facilitate prescription only and equitable access to antimicrobials.

6.2.2 *South Africa*

Short-Term

- By 2022, to have conducted a formal review of use of growth promoters in the farming sector and the implications of legislation banning the non-therapeutic use of antimicrobials in the food production industry.

- By 2022, for the SA government to have launched a multi-modal multi-year nation-wide public awareness campaign on AMR. This should be tailored to reach different age groups and sectors of the population.

- By 2022, for SA to have developed a published workforce strategy to educate, recruit, and retain the necessary personnel to implement the NAP including veterinarians, veterinarians' assistants, infection control nurses, microbiologists, and infectious disease specialists, incorporating both the public and private healthcare sector.

Medium-Term

- By 2023, for SA to have rationalised current legislation, so there is a uniform policy that bans the non-therapeutic use of antimicrobials in animal health, and introduces the compulsory requirement for a prescription by a veterinarian for access to antimicrobials

- By 2023, to have developed and implemented a nationwide IPC continuing education programme for the workforce in the animal health sector, including veterinarians and farmers.

- By 2023, to have enhanced surveillance of AMR in a manner that facilitates the benchmarking of both public and private healthcare providers according to the quality of their antimicrobial prescribing, with subsequent publication in the public domain.

- By 2024, to have set up a system for AMU and AMR surveillance in the animal/farming sector with the ultimate aim of integrating this system with that which already exists for the human health sector.

6.2.3 *Russia*

Short-Term

- By 2022, to have launched a nationwide educational campaign for veterinarians and agricultural workers on the issue of AMR to ensure sustainable engagement and implementation of recent legislative efforts to prohibit the use of antimicrobials for non-therapeutic purposes in agriculture.

- To partner with other countries and international organisations to secure necessary funding to fund both pre-clinical and clinical research for novel antimicrobials and alternative treatments such as bacteriophages in both human and animal health sectors.

- For the Ministry of Agriculture to partner with livestock industry to increase investment in the development and implementation of a consistent nationwide approach to infection control and stewardship of antimicrobials in livestock production, that takes accounts of the Russian conditions of intensive production characterized by a high concentration of livestock.

Medium-Term

- To develop and publish a multi-year implementation strategy to develop an integrated and interagency surveillance system as a major enabler to achieve other objectives in the Russian NAP.

- By 2023, to have developed a surveillance system that incorporates national, regional and organisational estimates of antimicrobial usage in both hospitals and the community, including outpatient clinics and community pharmacies. This will require investment in strengthening health information technology systems across the healthcare system.

- By 2025, to have achieved the aforementioned integrated and interagency surveillance system and have published the first integrated surveillance report incorporating AMR and AMU data across the human, animal, and environmental health sectors. This will require engagement with the pharmaceutical industry to collection pharmaceutical sales data in animal health.

6.3 Monitoring and evaluation

6.3.1 *Egypt*

Short-Term

- To publicly publish and widely disseminate a report detailing progress in achieving stated objectives contained within the Egyptian NAP, with the aim to inform the development of the next Egyptian NAP.

- In collaboration with the agricultural industry to invest in research activities which demonstrates the cost-effectiveness of alternative strategies of herd management and biosecurity measures in livestock without the routine use of antimicrobials as growth promoters.

- For the Ministry of Health to launch a funding call to partner with academic institutions to establish a research centre responsible to understanding the origins, drivers, and solutions to tackling AMR in the Egyptian context.

Medium-Term

- In parallel to investing in surveillance systems feedback mechanisms to relay AMR and AMU data to hospitals, community sites, and agricultural settings should be developed.

- For the next Egyptian NAP to include a commitment to publish two-yearly progress reports on the state of AMR in Egypt, and on progress with the stated strategic objectives of the NAP.

6.3.2 *South Africa*

Short-Term

- By the end of 2021, yearly progress reports should be produced both on the state of AMR in South Africa, and on progress with the stated strategic objectives of the NAP.

- Similar to Egypt, for South Africa to invest in research activities in collaboration with the agricultural industry which demonstrates the cost-effectiveness of alternative strategies of herd management and biosecurity measures in livestock without the routine use of antimicrobials as growth promoters.

Medium-Term

- To expand the South African Centre for the Study of Antimicrobial Resistance (CAMRA) with additional academic partners, and earmarked funding, to focus on evaluating the effectiveness and cost-effectiveness of alternative strategies to tackle AMR in the South African setting.

- By 2023, to have a developed a system in animal health, modelled on human health, whereby there are provincial antimicrobial stewardship committees, with involvement of veterinarians, and agricultural workers, that discuss surveillance and/or sales data, which feedbacks to a suitable national authority.

6.3.3 *Russia*

Short-Term

- By end of 2021, to have publicly published and widely disseminated a report that detail progress in achieving stated objectives and deadlines contained within the Russian NAP, and to update timelines and objectives that have been affected by the Covid-19 pandemic.

Medium-Term

- To invest in research to establish the effectiveness, compliance and stakeholder engagement with recent legislation which bans the use of non-therapeutic use of antimicrobials in animal health.

- By 2023, to have strengthened the AMRmap and AMRCloud platforms through additional funding by expanding coverage of surveillance data and the inclusion of proactive feedback mechanism at regional and organisation level in both human and animal health.

Appendix I: AMR Governance Framework Indicators

Policy Design Domains & Indicators	
1 - Strategic Vision	
Indicator 1	*Has a situational analysis been conducted to determine the prevalence and incidence of AMR organisms in the country?*
2	*Is a national action plan (NAP) in place, if not what is the timeframe for developing and implementing the NAP?*
3	*Are the objectives contained within the NAP specific, measurable and time-bound?*
4	*Are there quantitative targets for AMR/antimicrobial use outlined in the NAP?*
2 - Coordination	
5	*Is coordination between sectors and across different levels of each sector considered?*
6	*Is there a ministry and/or intersectoral committee responsible for coordination and implementation?*
3 - Participation	
7	*Was a high level of stakeholder participation facilitated throughout the development of the NAP?*
8	*Are the activities in the NAP inclusive across all 'One Health'-related sectors? If so, how, and if not, why not?*
9	*Was there support from a technical advisory group or subject matter experts during development of the NAP?*
4 - Accountability	
10	*Is there an ministry and/or intersectoral committee responsible for coordination and implementation which is accountable to the Government?*
11	*Is a responsible person nominated in each sector and do agreements exist regarding what happens if objectives are not met?*
5 - Transparency	
12	*Is the complete NAP publicly available?*
13	*Are all progress reports publicly available?*
14	*Is all funding information publicly available?*
15	*Is all AMR/antimicrobial use surveillance data publicly available ?*
6 - Sustainability	
16	*Is there either a written mandate or voluntary agreement from all relevant sectors in place to implement the NAP?*
17	*Are there dedicated budgets in place to implement specific activities in the NAP?*
18	*Is there an assessment of future budget requirements for different activities listed in the NAP?*

19	*Is there ongoing support from a technical advisory group or subject matter experts during implementation, monitoring and evaluation of the NAP?*
7 - Equity	
20	*Does the NAP include both encouraging responsible use and facilitating equitable access to existing essential antimicrobials?*

Implementation Domains & Indicators	
8 - Surveillance	
Indicator 21	*Is there a national surveillance system for resistant organisms across the human, animal, and the environmental health sectors?*
22	*Is there a national surveillance system for levels of antimicrobial use in animals and humans?*
23	*Is there adequate laboratory capacity and capability supported by regular external quality assessments?*
9 - Antimicrobial Stewardship	
24	*Are there stewardship programmes across human and animal health sectors?*
25	*Are rapid diagnostic tools widely available and in regularly use?* *if so, do national guidelines regarding their indication and interpretation exist?*
26	*Are there up-to-date national guidelines on antimicrobial use and rapid diagnostic tools across a wide range of settings in animal and human health?*
27	*Is there any use of financial and non-financial incentives/penalties in animal and human health to reduce inappropriate use of antibiotics?*
10 - Infection Prevention and Control	
28	*Are there IPC policies across all levels of human, animal and environmental health sectors?*
29	*Are there up-to-date national guidelines for IPC across human, animal and environmental health sectors?*
30	*Are immunisation programmes utilised as an approach to prevent infections across human and animal health sectors?*
31	*Are financial and non-financial incentives/penalties for IPC policies utilised across human, animal and environmental health?*
11 - Education	
32	*Is there certifications or programmes in place to ensure a basic education for all involved groups of professionals to deliver necessary understanding for strategies to tackle AMR?*
33	*Is there continuing education programmes for all involved groups of professionals to ensure expertise necessary for expanding knowledge and sustained efforts to tackle AMR?*
34	*Is there a workforce strategy which aims to deliver the sustainable supply of the necessary workforce required to deliver antimicrobial stewardship and IPC policies?*

12 - Public Awareness	
35	*Are there multi-modal public awareness campaigns that focus on AMR and educational programmes (including school children) related to AMR?*
36	*Do the implemented public awareness campaigns have an ongoing character?*
37	*Does the conception of the public awareness campaign consider aspects of behavioural sciences, social science and psychology?*
13 - Medicines Regulation	
38	*Are there regulations in place to ensure appropriate use of antimicrobials in human health?*
39	*Are there regulations in place to ensure appropriate use of antimicrobials in animal health?*
40	*Is there an authority in place to monitor and enforce legislation, if so does this authority have a dedicated budget?*
14 - Fostering R&D and Facilitating Market Access to Novel Products	
41	*Is fostering R&D and facilitating market access to novel antimicrobials, diagnostics, vaccines and alternative treatments in both human and animal health listed as a priority in NAP?*
42	*Does the NAP consider how the country can contribute to R&D of novel agents at both a national and international level?*
43	*Is there a dedicated national budget for R&D of novel antimicrobials, diagnostics, vaccines, or alternative treatments?*

Monitoring and Evaluation Domains & Indicators	
15 - Reporting	
Indicator 44	*Are annual AMR NAP progress reports published?*
45	*Are annual surveillance reports published containing data regarding the incidence of resistant organisms and antimicrobial use?*
46	*Is there collaboration with and systematic data transmission to international surveillance systems?*
16 - Feedback Mechanisms	
47	*Are there feedback mechanisms in place which relay surveillance data back at both regional and organisational level?*
48	*Are there regular deadlines in place to review progress of specific actions within the NAP, and arrangements to feedback at both regional and organisation level?*
17 - Effectiveness	
49	*Have there been efforts to evaluate the effectiveness (e.g. measure of impact on human and animal health) of specific policies and/or interventions implemented?*

50	*Have there been efforts to evaluate the cost-effectiveness (e.g. measure of impact on human and animal health) of specific policies and/or interventions implemented?*
18 - AMR Research	
52	*Is research to understand both the drivers and impact of AMR as well as potential policies and interventions identified as a key priority in the NAP?*
52	*Is there a dedicated national budget for AMR research in place?*

Appendix II: STAKEHOLDERS INTERVIEWED

Egypt	**South Africa**	**Russia**
Dr. Luay Elsayed Ahmed Zonkle, Director of Biosafety Department, Ministry of Environment.	Professor Adrian Brink, Professor of the Division Medical Microbiology, National Health Laboratory Services, University of Cape Town	Dr. Svetlana V. Shchepetkina, Head of Scientific Advisory Center on the Development and Transfer of System Technologies in Veterinary Medicine and Agriculture
Dr. Zelalem Tadesse – ECTAD Team Leader- FAO- Egypt	Prof James Wabwire Oguttu, Associate Professor, College of Agriculture & Environmental Sciences, University of South Africa	Professor Roman S.Kozlov Chief Specialist of Ministry of Health of Russian Federation on Clinical Microbiology & Antimicrobial Resistance
Dr. Abdel Hakam Ali, Head of the Veterinary Services, Ministry of Agriculture and Land Reclamation	Non Smit, Director of Multiple Sclerosis South Africa	Professor Lyalya Gabbasova, Deputy Director of Medical scientific learning center, Lomonosov Moscow state university (MSU) Former Assistant to the Minister of Health for AMR issues, and infectious diseases management
Professor Adel A El Sayed, President of the Egyptian NCD Alliance (EgNCDA)	Vanessa Carter, Advisor: South African Antibiotic Stewardship Program (SAASP) Civil Society Champion at the Africa CDC, African Union	Sergey Golovin, Make Medicines Affordable coordinator for Eastern Europe and Central Asia (EECA)
Dr Soha Namzy, Egyptian Association for Care of Heart Failure Patients (EACHFP)		Tatyana Khan, Senior Program Manager Treatment Preparedness Coalition (ITPC.ru)
Dr. Ahmed Saad, Deputy ECTAD Team leader- FAO - Egypt		

References

1 World Health Organization. Global Action Plan On Antimicrobial Resistance. 2015 http://apps.who.int/iris/bitstream/handle/10665/193736/9789241509763_eng.pdf?sequence=1 (accessed Dec 7, 2020).

2 Interagency Coordination Group on Antimicrobial Resistance. Antimicrobial resistance: national action plans IACG Discussion Paper. 2018; published online June. https://www.who.int/antimicrobial-resistance/interagency-coordination-group/IACG_AMR_National_Action_Plans_110618.pdf. (accessed Dec 7, 2020)

3 Holmes AH, Moore LSPP, Sundsfjord A, *et al.* Understanding the mechanisms and drivers of antimicrobial resistance. *The Lancet* 2016; **387**: 176–87.

4 Teillant A, Gandra S, Barter D, Morgan DJ, Laxminarayan R. Potential burden of antibiotic resistance on surgery and cancer chemotherapy antibiotic prophylaxis in the USA : *The Lancet Infectious Diseases* 2015; **3099**: 1–9.

5 Cassini A, Högberg LD, Plachouras D, *et al.* Attributable deaths and disability-adjusted life-years caused by infections with antibiotic-resistant bacteria in the EU and the European Economic Area in 2015: a population-level modelling analysis. *The Lancet Infectious diseases* 2018; **0**. DOI:10.1016/S1473-3099(18)30605-4.

6 O'Neill J. Tackling drug-resistant infections globally: final report and recommendations. The Review on Antimicrobial Resistance. 2016. https://amr-review.org/sites/default/files/160518_Final%20paper_with%20cover.pdf (accessed Dec 7, 2020)

7 UN General Assembly. High-Level Plenary Meeting on Antimicrobial Resistance. 2016. https://digitallibrary.un.org/record/842813?ln=en (accessed Dec 6, 2020).

8 WHO. Global Antimicrobial Resistance and Use Surveillance System (GLASS). 2021. https://www.who.int/data/gho/data/themes/topics/global-antimicrobial-resistance-surveillance-system-glass/glass-country-profiles (accessed Sept 17, 2021).

9 Center for Disease Dynamics, Economics & Policy. ResistanceMap. https://resistancemap.cddep.org/ (accessed Jan 6, 2021).

10 WHO. WHO Regional Office for Europe Antimicrobial Medicines Consumption (AMC) Network: AMC data, 2014-2018 (2021). 2021. https://www.euro.who.int/en/publications/abstracts/who-regional-office-for-europe-

antimicrobial-medicines-consumption-amc-network-amc-data,-2014-2018-2021 (accessed Sept 17, 2021).

11 ECDC. Antimicrobial consumption database (ESAC-Net). 2021. https://www.ecdc.europa.eu/en/antimicrobial-consumption/surveillance-and-disease-data/database (accessed Sept 17, 2021).

9 Food and Agriculture Organization of the United Nations. Debate in the Federation Council focuses on antimicrobial resistance (AMR). 2019. http://www.fao.org/russian-federation/news/detail-events/en/c/1251884/ (accessed Dec 9, 2020).

10 World Health Organisation. Finalizing the national action plan on antimicrobial resistance in Egypt. 2018. http://www.emro.who.int/egy/egypt-infocus/finalizing-the-national-action-plan-on-antimicrobial-resistance-in-egypt.html (accessed Dec 9, 2020).

11 Republic of South Africa Department of Health. Antimicrobial Resistance National Strategy Framework 2014-24. 2014. https://www.jpiamr.eu/wp-content/uploads/2018/10/Antimicrobial-Resistance-National-Strategy-Framework-2014-2024_South-Africa.pdf (accessed Dec 9, 2020).

12 WHO, OIE, FAO. Global Database for Antimicrobial Resistance Country Self Assessment. 2018. https://amrcountryprogress.org/ (accessed Dec 6, 2020).

16 Anderson M, Schulze K, Cassini A, Plachouras D, Mossialos E. A governance framework for development and assessment of national action plans on antimicrobial resistance. *The Lancet Infectious Diseases* 2019; **19**: e371–84.

17 The Arab Republic of Egypt. National Action Plan For Antimicrobial Resistance (2018-2022). 2018. https://www.who.int/publications/m/item/egypt-national-action-plan-for-antimicrobial-resistance (accessed March 20, 2021).

15 Department of health, Department of agriculture forestry and fisheries. South African Anitmicrobial Resistance National Strategy Framefork: A One Health Approach 2018-2024. 2018 https://www.who.int/docs/default-source/antimicrobial-resistance/south-africa-antimicrobial-resistance-national-action-plan-2018---2024.pdf?sfvrsn=533118b0_1&download=true (accessed Dec 7, 2020)

19 Russian Federation. Strategy for preventing the spread of antimicrobial resistance in the Russian Federation for the period up to 2030. 2017. http://extwprlegs1.fao.org/docs/pdf/rus186961.pdf (accessed Oct 27, 2020).

20 Russian Federation. Plan of Events for 2019 - 2024 on the implementation of the Strategy for preventing the spread of antimicrobial resistancein the Russian Federation for the period up to 2030. 2019. http://government.ru/docs/36320/ (accessed Dec 11, 2020).

18 Department of Health, Republic of South Africa. Implementation Plan for Antimicrobial Resistance Strategy Framework in South Africa (2014-2019). https://www.knowledgehub.org.za/elibrary/implementation-plan-antimicrobial-resistance-strategy-framework-south-africa-2014-2019 (accessed Dec 7, 2020)

19 Department of Health, Republic of South Africa. Guidelines on Implementation of the Antimicrobial Strategy in South Africa: One Health Approach & Governance. 2017.

https://www.knowledgehub.org.za/elibrary/guidelines-implementation-antimicrobial-strategy-south-africa-one-health-approach (accessed Dec 7, 2020)

20 Department of Health, Republic of South Africa. Antimicrobial Resistance Background Document. 2019. https://www.knowledgehub.org.za/elibrary/antimicrobial-resistance-background-document (accessed Dec 7, 2020)

24 Crowther-Gibson P, Govender N, Lewis DA, *et al.* Situation analysis: Antibiotic use and resistance in South Africa. *S Afr Med J* 2011; **101**: 549–96.

25 Dooling KL, Kandeel A, Hicks LA, *et al.* Understanding Antibiotic Use in Minya District, Egypt: Physician and Pharmacist Prescribing and the Factors Influencing Their Practices. *Antibiotics (Basel)* 2014; **3**: 233–43.

26 El Kholy A, Baseem H, Hall GS, Procop GW, Longworth DL. Antimicrobial resistance in Cairo, Egypt 1999–2000: a survey of five hospitals. *J Antimicrob Chemother* 2003; **51**: 625–30.

27 Shaban L, Siam R. Prevalence and antimicrobial resistance pattern of bacterial meningitis in Egypt. *Ann Clin Microbiol Antimicrob* 2009; **8**: 26.

28 Ashour HM, El-Sharif A. Species distribution and antimicrobial susceptibility of gram-negative aerobic bacteria in hospitalized cancer patients. *J Transl Med* 2009; **7**: 14.

29 Talaat M, El-Shokry M, El-Kholy J, *et al.* National surveillance of health care–associated infections in Egypt: Developing a sustainable program in a resource-limited country. *American Journal of Infection Control* 2016; **44**: 1296–301.

30 Talaat M, Saied T, Kandeel A, *et al.* A Point Prevalence Survey of Antibiotic Use in 18 Hospitals in Egypt. *Antibiotics (Basel)* 2014; **3**: 450–60.

31 El-Sharkawy H, Tahoun A, El-Gohary AE-GA, *et al.* Epidemiological, molecular characterization and antibiotic resistance of Salmonella enterica serovars isolated from chicken farms in Egypt. *Gut Pathog* 2017; **9**. DOI:10.1186/s13099-017-0157-1.

32 Ombarak RA, Hinenoya A, Elbagory A-RM, Yamasaki S. Prevalence and Molecular Characterization of Antimicrobial Resistance in Escherichia coli Isolated from Raw Milk and Raw Milk Cheese in Egypt. *J Food Prot* 2018; **81**: 226–32.

33 Composition of the profile commission of the Ministry of Health of the Russian Federation on Clinical Microbiology and Antimicrobial Resistance. 2015. http://www.antibiotic.ru/minzdrav/news/structure-of-the-profile-commission-20150916/ (accessed Oct 27, 2020).

34 FAO Liaison Office for the Russian Federation. Attention: Antimicrobials. Use carefully! 2020. http://www.fao.org/russian-federation/news/detail/ru/c/1334048/ (accessed Dec 29, 2020).

32 National Department of Health, Republic of South Africa. Surveillance for Anitmicrobial Resistance and Consumption of Anitibiotics in South Africa. 2018. https://www.knowledgehub.org.za/elibrary/surveillance-antimicrobial-resistance-and-consumption-antibiotics-south-africa (accessed Dec 7, 2020)

36 AMRmap. https://amrmap.net/ (accessed Oct 27, 2020).

37 Belkova YA, Rachina SA, Kozlov RS, *et al.* [Systemic Antimicrobials Consumption and Expenditures in Departments of Surgery of Multi-Profile Hospitals in the Russian Federation and the Republic of Belarus: Results of Multicentre Pharmacoepidemiological Study]. *Antibiot Khimioter* 2016; **61**: 15–31.

38 Rachina S, Belkova Y, Kozlov R, *et al.* Longitudinal Point Prevalence Survey of Antimicrobial Consumption in Russian Hospitals: Results of the Global-PPS Project. *Antibiotics* 2020; **9**: 446.

39 Moawad AA, Hotzel H, Neubauer H, *et al.* Antimicrobial resistance in Enterobacteriaceae from healthy broilers in Egypt: emergence of colistin-resistant and extended-spectrum β-lactamase-producing Escherichia coli. *Gut Pathog* 2018; **10**. DOI:10.1186/s13099-018-0266-5.

40 Elkenany R, Elsayed MM, Zakaria AI, El-sayed SA-E-S, Rizk MA. Antimicrobial resistance profiles and virulence genotyping of Salmonella enterica serovars recovered from broiler chickens and chicken carcasses in Egypt. *BMC Vet Res* 2019; **15**. DOI:10.1186/s12917-019-1867-z.

41 Hamed OM, Sabry MA, Hassanain NA, Hamza E, Hegazi AG, Salman MB. Occurrence of virulent and antibiotic-resistant Shiga toxin-producing Escherichia coli in some food products and human stool in Egypt. *Vet World* 2017; **10**: 1233–40.

42 Seedy FRE, Samy AA, Salam HSH, Khairy EA, Koraney AA. Polymerase chain reaction detection of genes responsible for multiple antibiotic resistance Staphylococcus aureus isolated from food of animal origin in Egypt. *Vet World* 2017; **10**: 1205–11.

43 Single nucleotide polymorphisms (SNPs) typing web application. http://snptab.antibiotic.ru/ (accessed Dec 11, 2020).

44 D.a M, S.Yu K, E.a K, *et al.* Experience with the AMRcloud online platform for antimicrobial resistance surveillance in zoonotic bacteria. *Клиническая микробиология и антимикробная химиотерапия* 2020; **22**: 53–9.

45 Lobova TI, Yemelyanova E, Andreeva IS, Puchkova LI, Repin VY. Antimicrobial Resistance and Plasmid Profile of Bacterial Strains Isolated from the Urbanized Eltsovka-1 River (Russia). *Microbial Drug Resistance* 2015; **21**: 477–90.

46 Russian Federation. Action Plan (the “Plan”) to Implement the Russian Federation Policy Framework for Chemical and Biological Safety Through 2025 and Beyond. 2019. http://docs.cntd.ru/document/561125462 (accessed Dec 11, 2020).

44 Rachina S. Antibiotic Use Surveillance in Russia: Current State and Prospects for Colloboration. 2015. http://bsac.org.uk/wp-content/uploads/2016/03/SvetlanaRachina-1.pdf (accessed Oct 27, 2020).

48 IACMAC. Clinical guidelines. http://www.antibiotic.ru/minzdrav/clinical-recommendations/ (accessed Oct 27, 2020).

49 FSVOK - Association of Specialists. Centre of External Quality Assurance. http://www.fsvok.ru/ (accessed Sept 17, 2021).

50 Saied T, Hafez SF, Kandeel A, *et al.* Antimicrobial stewardship to optimize the use of antimicrobials for surgical prophylaxis in Egypt: A multicenter pilot intervention study. *Am J Infect Control* 2015; **43**: e67-71.

48 Department of Health, Republic of South Africa. Guidelines for the prevention and containment of Antimicrobial Resistance in South African hospitals. 2018. https://www.knowledgehub.org.za/elibrary/guidelines-prevention-and-containment-antimicrobial-resistance-south-african-hospitals (accessed Dec 7, 2020)

52 Zamyatin M, Gusarov V, Petrova N, *et al.* Results of antimicrobial stewardship programme implementation in multidisciplinary hospital. HealthManagement. 2018. https://healthmanagement.org/c/icu/issuearticle/results-of-antimicrobial-stewardship-programme-implementation-in-multidisciplinary-hospital (accessed Nov 1, 2020).

53 SKAT program (Antimicrobial Therapy Control Strategy) when providing stationary medical care: Russian Clinical Guidelines. 2017. http://antimicrob.net/wp-content/uploads/r_r_r_r_klinrekom_r_r_r_r_s_r_2_.pdf (accessed Dec 11, 2020).

54 Yakovlev SV, Briko NI, Sidorenko SV, Protsenko DN. SCAT program (Antimicrobial Therapy Control Strategy) in the provision of hospital care. 2018. https://www.twirpx.com/file/2762704/ (accessed Dec 11, 2020).

55 Antimicrobial control system (SCAMP) - general information. https://animal-health.ru/o-skamp/ (accessed Dec 29, 2020).

56 Standard Treatment Guidelines and Essential Medicines List for South Africa. https://www.sapc.za.org/Media/Default/Documents/STG%20hospital%20level%20adult%202019_v2.0.pdf (accessed Nov 11, 2020).

54 Wasserman S, Boyles T, Mendelson M, A Pocket Guide to Antibiotic Prescribing for Adults in South Africa. South African Antibiotic Stewardship Programme. 2014. https://sahivsoc.org/Files/Guide%20to%20Antibiotice%20prescribing%20for%20adults%20in%20SA_2014%20(Oct%202014).pdf (accessed 27 March 2021)

58 Strachunsky LS, Belousouva YuB, Kozlova SN. Anti-infective chemotherapy. A practical guide. http://www.antibiotic.ru/ab/mq.shtml (accessed Oct 27, 2020).

59 IACMAC. Diagnosis and antimicrobial therapy of infections caused by multidrug resistant microorganisms. 2019. http://www.antibiotic.ru/files/pdf/2019/guidelines-daticmm-20191204.pdf (accessed Dec 11, 2020).

60 WHO EMRO, Ministry of Health. National manual on Infection Control: standard precautions for Infection Control. 2005. https://apps.who.int/iris/handle/10665/119757?locale-attribute=de& (accessed Dec 29, 2020).

61 WHO EMRO, Ministry of Health. National Infection Control Manual : infection control in the various sections of the health institution. 2005. https://apps.who.int/iris/handle/10665/119732 (accessed Dec 29, 2020).

62 National Infection Prevention and Control Strategic Framework March 2020.pdf. https://www.knowledgehub.org.za/system/files/elibdownloads/2020-

04/National%20Infection%20Prevention%20and%20Control%20Strategic%20Framework%20March%202020.pdf (accessed Nov 11, 2020).

63 Practical Manual for implementation of the National IPC Strategic Framework March 2020.pdf. https://www.idealhealthfacility.org.za/docs/Manuals-and-Handbooks/Practical%20Manual%20for%20implementation%20of%20the%20National%20IPC%20Strategic%20Framework%20March%202020.pdf (accessed Nov 11, 2020).

64 Shestopalov N, Akimkin V, Panteleeva L, Fedorova L, Abramova I. Measures for disinfection and sterilization as the most significant concept in health care infection control system in Russia. *Antimicrobial Resistance and Infection Control* 2015; **4**: P47.

65 Kaftyreva LA, Zueva LP, Kolosovskaya EN, *et al.* Principles of organizing monitoring of the resistance of leading infections associated with health care: Federal Clinical Guidelines. NASCI, 2014 http://nasci.ru/?id=3374 (accessed Dec 11, 2020).

66 Rosselkhoznadzor. The list of regulatory documents permitted for use in state veterinary laboratories in the diagnosis of animal diseases, in quality control and safety of raw materials of animal and vegetable origin, feed. 2011. http://docs.cntd.ru/document/1200117681 (accessed Dec 11, 2020).

67 International Solid Waste Association. Recap of the First International Conference on Medical Waste Management in Russia. 2019. https://www.iswa.org/home/news/news-detail/browse/7/article/recap-of-the-first-international-conference-on-medical-waste-management-in-russia-moscow19-march-2/109/ (accessed Nov 1, 2020).

68 Akimkin VG, Bormashov AV. Epidemiology and Infectious Diseases » Problems in medical waste disposal in the Russian Federation: State-of-the-art and solution prospects. *Epidemiology and Infection Diseases* 2013. https://epidemiology-journal.ru/en/archive/article/11791 (accessed Nov 1, 2020).

66 Department of Health South Africa, Expanded Programme on Immunisation. New EPI vaccines guidelines. 2010. https://ndoh.dhmis.org/owncloud/index.php/s/R5cmdp0gY4Fa43Z?path=%2FChidrens%20Vaccines (accessed Nov 11, 2020).

67 Frean J, Cloete A, Rossouw J, et al 2018. Brucellosis in South Africa- A notifiable medical condition. https://www.nicd.ac.za/wp-content/uploads/2018/12/Brucellosis.pdf (accessed March 23, 2021)

68 Department of Agriculture, Republic of South Africa. Goats: Vaccination Programme. https://www.nda.agric.za/docs/Infopaks/goats.pdf (accessed Nov 11, 2020).

69 Humansdorp Veterinary Clinic. Beef Cattle - Vaccination Programme. http://www.humvet.co.za/index.php/biosecurity/vaccination-programmes/beef (accessed Nov 11, 2020).

70 Poultry Club South Africa. Vaccination Program. https://www.poultryclubsa.co.za/vaccination-program-2/ (accessed Nov 11, 2020).

74 WHO. WHO vaccine-preventable diseases: monitoring system. 2020 global summary. 2020. https://apps.who.int/immunization_monitoring/globalsummary/countries?countrycriteria[country][]=RUS (accessed Nov 1, 2020).

75 Denisov AA, Sclyarov OD, Salmakov KM, Shumilov KV. The Russian experience in brucellosis veterinary public health. *Rev Sci Tech* 2013; **32**: 229–37.

76 Rosselkhoznadzor. Vaccination Monitoring. https://fsvps.gov.ru/fsvps/ya/monitoring/ (accessed Dec 11, 2020).

77 EACMED. http://www.cmeegypt.org/ (accessed Nov 1, 2020).

78 IACMAC events. http://www.antibiotic.ru/iacmac/ru/confer/ (accessed Oct 27, 2020).

79 IACMAC. Specialty 'Medical Microbiology'. http://www.antibiotic.ru/minzdrav/news/specialty-medical-microbiology-20201002/ (accessed Oct 27, 2020).

80 Kandeel A, Palms DL, Afifi S, *et al.* An educational intervention to promote appropriate antibiotic use for acute respiratory infections in a district in Egypt- pilot study. *BMC Public Health* 2019; **19**: 498.

78 Department of Health, Republic of South Africa. National hand hygiene behaviour change strategy 2016-2020. https://www.knowledgehub.org.za/system/files/elibdownloads/2020-10/national%20hand%20hygiene%20behaviour%20change%20strategy_2016-2020_final_4.pdf (accessed Nov 11, 2020).

82 Antibiotics. http://www.antibiotic-save.ru/ (accessed Oct 27, 2020).

83 Sabry NA, Farid SF, Dawoud DM. Antibiotic dispensing in Egyptian community pharmacies: an observational study. *Res Social Adm Pharm* 2014; **10**: 168–84.

84 Schellack N, Benjamin D, Brink A, *et al.* A situational analysis of current antimicrobial governance, regulation, and utilization in South Africa. *International Journal of Infectious Diseases* 2017; **64**: 100–6.

82 Department of Agriculture, Forestry & Fisheries, Republic of South Africa. South African Veterinary Strategy 2016-2026. https://www.daff.gov.za/vetweb/Animal%20Identification/Veterinary%20Strategy%20%202016-09-08_%20(Final).pdf (accessed Nov 10, 2020).

86 Eagar H, Swan G, van Vuuren M. A survey of antimicrobial usage in animals in South Africa with specific reference to food animals. *Journal of the South African Veterinary Association* 2012; **83**: 15–23.

84 South African Health Products Regulatory Authority. https://www.sahpra.org.za/ (accessed Nov 11, 2020).

88 Nordic model for rational use of antibiotics in Russia. Finnish Institute for Health and Welfare (THL). 2019. https://thl.fi/en/web/thlfi-en/-/nordic-model-for-rational-use-of-antibiotics-in-russia (accessed Oct 27, 2020).

89 Belkina T, Duvanova N, Karbovskaja J, Tebbens JD, Vlcek J. Antibiotic use practices of pharmacy staff: a cross-sectional study in Saint Petersburg, the Russian Federation. *BMC Pharmacology and Toxicology* 2017; **18**: 11.

90 Government of the Russian Federation. Order 604. 2019. http://publication.pravo.gov.ru/File/GetFile/0001201904090021?type=pdf (accessed Oct 27, 2020).

91 Eurasian Economic Committee. Position On A Uniform Procedure For Implementing Veterinary Control (Supervision) At The Customs Border Of The Eurasian Economic Union And On The Customs Territory Of The Eurasian Economic Union. 2010. https://www.alta.ru/tamdoc/10sr0317/ (accessed Dec 11, 2020).

92 Eurasian Economic Commission. Decision of the Council of the Eurasian Economic Commission of 09.10.2013 N 68 "On the technical regulations of the Customs Union on the safety of meat and meat products ". 2013. http://www.consultant.ru/document/cons_doc_LAW_153234/ (accessed Dec 11, 2020).

93 Eurasian Economic Commission. Decision of the Board of the Eurasian Economic Commission dated February 13, 2018 N 28 'On the maximum permissible levels of residues of veterinary medicinal products (pharmacologically active substances) that may be contained in unprocessed food products of animal origin, including raw materials, and methods for their determination'. 2018. https://www.alta.ru/tamdoc/18kr0028/ (accessed Dec 11, 2020).

94 United States Department of Agriculture. Russian Veterinary Situation Update. 2020. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Russian%20Veterinary%20Situation%20Update_Moscow_Russian%20Federation_07-07-2020 (accessed Oct 27, 2020).

95 Medical Research Council MRC. South Africa-UK AMR Drug Discovery Partnership Hub Initiative - workshop. 2019; published online June 14. https://mrc.ukri.org/about/events/south-africa-uk-workshop/ (accessed Nov 11, 2020).

96 Myelnikov D. An Alternative Cure: The Adoption and Survival of Bacteriophage Therapy in the USSR, 1922–1955. *J Hist Med Allied Sci* 2018; **73**: 385–411.

97 Drug Discovery Today. UK and Russian researchers join forces against AMR. 2017. http://www.drugdiscoverytoday.com/view/47438/uk-and-russian-researchers-join-forces-against-amr/ (accessed Oct 27, 2020).

95 WHO. Global Health Observatory. https://www.who.int/Global Health Observatory (accessed Nov 11, 2020).

99 Afdal A. AMS Case Study- Egypt (National Antimicrobial Stewardship Program). 2020. https://mena-ams.com/wp-content/uploads/2020/02/Egypt-case-study.pdf (accessed Dec 29, 2020).

100 Junaid E, Jenkins L, Swanepoel H, North Z, Gould T. Antimicrobial stewardship in a rural regional hospital – growing a positive culture. *South African Medical Journal* 2018; **108**: 546-550–550.

101 Brink AJ, Messina AP, Feldman C, Richards GA, van den Bergh D, Alliance on behalf of the NASS. From guidelines to practice: a pharmacist-driven prospective audit and feedback improvement model for peri-operative antibiotic prophylaxis in 34 South African hospitals. *J Antimicrob Chemother* 2017; **72**: 1227–34.

102 Brink AJ, Messina AP, Feldman C, *et al.* Antimicrobial stewardship across 47 South African hospitals: an implementation study. *The Lancet Infectious Diseases* 2016; **16**: 1017–25.

103 Boyles TH, Naicker V, Rawoot N, Raubenheimer PJ, Eick B, Mendelson M. Sustained reduction in antibiotic consumption in a South African public sector hospital; Four year outcomes from the Groote Schuur Hospital antibiotic stewardship program. *South African Medical Journal* 2017; **107**: 115-118–118.

104 Boyles TH, Whitelaw A, Bamford C, *et al.* Antibiotic Stewardship Ward Rounds and a Dedicated Prescription Chart Reduce Antibiotic Consumption and Pharmacy Costs without Affecting Inpatient Mortality or Re-Admission Rates. *PLOS ONE* 2013; **8**: e79747.

105 Chetty S, Reddy M, Ramsamy Y, Naidoo A, Essack S. Antimicrobial stewardship in South Africa: a scoping review of the published literature. *JAC-Antimicrobial Resistance* 2019; **1**. DOI:10.1093/jacamr/dlz060.

106 Ershova K, Savin I, Kurdyumova N, *et al.* Implementing an infection control and prevention program decreases the incidence of healthcare-associated infections and antibiotic resistance in a Russian neuro-ICU. *Antimicrobial Resistance & Infection Control* 2018; **7**: 94.

107 Shchepetkina S.V. Principles of the antimicrobial control system organisation in veterinary medicine and agricuktural of the Russain Federation. *Journal of Integrated OMICS a methodological journal* 2019; **9**: 40–1.

108 Shchepetkina, S.V. Genotyping of microorganisms is a tool for controlling the epizootic situation, pathways and sources of the causative agent of infection. 2017 http://bsaa.edu.ru/InfResource/library/Journal_4_2017.pdf (accessed Sept 17, 2021).

109 S. V. Shchepetkina, V. V. Ponomarenko. Organization of Infectious Diseases Control System, Application of Antimicrobial Preparations and Production of Safe Poultry Products. 2020: 698–700.