Communication, information and knowledge exchange in the prevention of antimicrobial resistance in South Africa and worldwide: a narrative bioethical review.

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Abstract

Current study uses the method of narrative review and the method of bioethical analysis to evaluate the status of management antimicrobial resistance in South Africa and globally. Specific focus is placed on the evaluation of the alignment of the strategic, operational and tactical decision-making between international, regional national and sub-national level of planning decision-making, data and information exchange, and mechanisms to minimise human suffering due to antimicrobial resistance. Antimicrobial resistance is looked at as a feedback loop which results from the irrational prescribing an overuse of antimicrobial medicines by humanity, and through the lens of the *utilitarian qubit*. Results of the study indicate that the World Health Organisation and other international, or regional organisations stimulate collaboration and create/operationalise platforms that allow for efficient exchange of information about antimicrobial resistance. Limitations exist in the antimicrobial resistance testing and linking of prescribing and dispensing of antimicrobial agents in low- and middle-income countries. Solutions are proposed to address the gaps at the tactical level of decision-making and to deal with uncertainty antimicrobial resistance development in the future. These include of targeted training mechanisms, which are legislated at the national level of government, and which empower frontline healthcare workers. These training programmes should be supplemented by the use communicative ecology in data gathering, and information sharing. It is also

important to drive behavioural rigor in prescribing, dispensing, and therapeutic uses of antimicrobial medicines in public healthcare systems. Finally, health literacy of all stakeholders should be continuously monitored in relation to antimicrobial resistance.

Keywords: utilitarian qubit, health threats, tactical decision-making, training, frontline healthcare workers.

Introduction

Definition of AMR and its significance in public health worldwide

Antimicrobial resistance (AMR) can be defined as follows

> *"Antimicrobial Resistance (AMR) occurs when bacteria, viruses, fungi and parasites no longer respond to antimicrobial medicines. As a result of drug resistance, antibiotics and other antimicrobial medicines become ineffective and infections become difficult or impossible to treat, increasing the risk of disease spread, severe illness, disability and death"* (WHO, 2023-2025).

This definition focuses on the lack of therapeutic efficacy of medicines that are antimicrobial agents. Antimicrobial medicines were developed mostly over the course of 20th century (Dhingra et al., 2020). Candidate antimicrobials were subjected to all the stages of the drug discovery pipeline, clinical testing and the manufacturers gained regulatory approval for the use of those agents in the treatment against various infectious diseases (Thai et al., 2023-2025). Genetic elements through which microorganisms obtain AMR properties have been present in the microbial world prior to the development of therapeutic antimicrobial agents (Agudo and Reche, 2024). However, antimicrobial resistance genes were a marginal and highly diluted genetic feature of microbial genomes, which only became expressed with high frequencies after the selection pressure due to the introduction of antimicrobials into human medicine and due to several environmental factors (Endale et al., 2023). Loss of efficacy of the antimicrobials, which have been approved and that are currently used in human medicine, can have devastating consequences for the therapeutic outcomes in the treatment of infectious diseases in humans. AMR is therefore a global health challenge and a threat, now causing more deaths than HIV/AIDS and malaria worldwide (World Economic Forum, 2022). Managing and tackling the impacts of AMR has gained significance and is of utmost urgency in the current public health landscape globally.

The Sustainable Development Goals (SDGs) implemented from 2015 aim to end poverty and inequality, protect the planet, ensure peace and prosperity amongst all people by 2030 (UNDP, 2022). Health targets and goals are also a major part of the SDGs, or they have direct or indirect implications on a variety of the SDGs, e.g. SDG 3 (UN, undated). Though AMR is not directly included in the SDGs, the SDGs place AMR in the context of a global public health and socioeconomic problem, and also acknowledge

that the continued growth of AMR may make it more difficult to achieve several SDGs (Gajdács et al., 2021). To provide a more complete picture here, twelve of 17 SDGs are (strongly) impacted by the emergence of AMR (ReAct, 2019; StopAMR, 2020; WHO, 2017b). Antibiotic consumption is acknowledged as one of the primary selection pressures on pathogens driving the emergence of AMR around the world (Hou et al., 2023; Llor & Bjerrum, 2014). In many nations, over 50 % of antibiotics are used inappropriately (WHO, 2019c). Between 2000 and 2010, there was a 36 % increase in the global consumption of antibiotics, of which 27.36 % was attributable to BRICS countries (Brazil, Russia, India, China, and South Africa; Van Boeckel et al., 2014). This is partially due to population growth, increased access to antibiotics, and the improved socio-economic status of BRICS countries as increased income results in increased use of medicines such as antimicrobials. However, the absence of functioning policies to ensure rational use of antibiotics and antimicrobials has increased the indiscriminate use and misuse of these therapeutic agents in most BRICS countries (Ghafur, 2015; Van Boeckel et al., 2014). A more recent study found that between 2000 and 2015, the overall antibiotic consumption increased by 65 %, from 21.1 to 34.8 billion defined daily doses worldwide, while the daily antibiotic consumption rate increased by 39 %, from 11.3 to 15.7 defined daily doses per 1,000 population (Klein et al., 2018). The increased use of antibiotics in the low- and middle-income countries (LMICs), with India, China, and Pakistan being the top three users among them, was the main factor driving the rise in antibiotic consumption worldwide (Klein et al., 2018). LMICs made up four of the top six nations with the highest rates of antibiotic consumption. Statistics indicate that the consumption of antibiotics in LMICs is quickly catching up to that of high-income countries. If this pattern continues, worldwide antibiotic consumption in 2030 is predicted to increase by up to 200 % from the anticipated 42 billion defined daily doses in 2015 (Klein et al., 2018). Despite antibiotic consumption driving AMR to a great extent, there are still gaps in the antimicrobial consumption data in some parts of the world (Laxminarayan et al., 2016; O'Neill, 2016). This complicates potential success of strategies to tackle AMR in specific regions, but it also indicates that AMR is a global problem. Tackling AMR and AMR management must therefore be approached at various levels of decision-making, resource allocation, and knowledge/data sharing.

The onset of the coronavirus disease of 2019 (COVID-19) has not only exacerbated societal injustices and economic hardships, but also significantly increased the use of antibiotics for patient treatment, potentially worsening the emergence of AMR. Most significantly, the administration of antibiotics, both therapeutically and prophylactically, to patients with COVID-19 was primarily occurring in the intensive care units (Gajdács et al., 2021). According to a recent study, 72 % of patients with COVID-19 who were admitted to the hospital received unnecessary antimicrobial medication, and only 8% of the patients had infections which required antimicrobial

therapy (Rawson et al., 2020). Such reports have raised the possibility of an outbreak or even an epidemic due to bacterial superinfection in COVID-19 patients (Lucien et al., 2021), and potentially during future pandemics. Implementation of a system for monitoring the consumption, prescribing and dispensing of antimicrobial therapeutic agents has been suggested as one of the possible ways to manage and minimise the occurrence of AMR. One such a system is the implementation of antimicrobial stewardship (AMS) and related advocacy. Implementing efforts to reduce the irrational use of antibiotics and limiting their use in patients with the most severe COVID-19 symptoms has been shown to be crucial in the management of AMR during the coronavirus pandemic (Chetty, 2021). On the other side and in response to the threat of COVID-19 spreading, there has been a growing understanding of the significance of AMS programmes, as well as infection prevention and control measures that could help reduce the microbial load and, consequently, the circulation of pathogens, and a reduction in AMR occurrence/clinical rates of diagnosis of AMR (Lucien et al., 2021).

Among other factors, AMR is also increasing due to the over-prescribing of antibiotics in general not just during COVID19 (WHO, 2018e). Since antibiotic consumption is strongly linked to the development of AMR, it is important to promote appropriate prescribing practices (Sartelli et al., 2020). Inappropriate prescribing results from a lack of education, lack of culture and sensitivity testing, as well as medication errors. AMS programmes reduce the unnecessary use of antibiotics and thus improve the quality of patient care and preventing the development of AMR (James et al., 2015). AMR was predicted to cause severe health consequences if serious global coordinated actions are not taken promptly (Laxminarayan et al., 2013). Broader understanding of AMR as a public health threat is necessary. This should cover the analysis of the historical landscape in which the AMR has been developing and related changes in the healthcare settings. Such an analysis must be complemented by examination of the healthcare system in the given jurisdiction, and considerations must be given to all the stakeholders in the AMR development and tackling. Voices heard here should include healthcare workers, patients and other relevant stakeholders. Finally, it is necessary to examine the policy environment and ethical landscape of the AMR development and management worldwide, regionally and in given countries, sub-national jurisdictions. Properties of AMR as a biological hazard, or a source of threats to human health and wellbeing, must be understood, as a foundation for the AMR-related action and decision-making.

AMR as a biological hazard and its practical implications

AMR is also a biological hazard properties, and this notion can be defined as follows

> *"Biological hazards are disease producing agents (pathogens) that can be transmitted to individuals through various routes of exposure (modes of transmission). Exposure to these hazards may result in acute or chronic health conditions."* (CDC, undated).

As a result, a microbial pathogen can be the source of the infection, i.e. the biological hazard is a biological entity/microorganism which can cause human and animal disease if the exposure route and the susceptibility or vulnerability of the infected population provide conducive conditions for pathogen entering the human or animal body. Conditions must also be conducive for the outbreak of an AMR-related disease, i.e. the human or animal patient must exist clinical symptoms of an infectious diseases due a drug-resistant pathogen. In addition, biological hazards can also include diseases that are caused by not the microorganism, but its product such as the botulinum toxin (Fujinaga, 2006). Humans and animals can also be exposed to biological hazards via vector transmission, e.g. of malaria and its causative agent – the protozoan *Plasmodium falciparum* through the *Anopheles spp.* mosquito vector (Kariuki et al., 2013; Adugna et al., 2021). In addition, zoonotic disease can develop in humans upon contact with animals, e.g. husbandry cattle as demonstrated for anthrax in developing countries (Ahmed et al., 2010) and in the Global North (Fasanella et al., 2010). Pathogens that are of critical clinical significance in terms of AMR include members of the ESKAPEE+ group (Mancuso et al., 2021). The most common transmission routes include the transmission through healthcare facilities, through human-animal contact (zoonotic diseases), through the environment, and through the food supply chain (CDC, 2025). Use of antibiotics as growth promoters in animal husbandry and environmental contamination are also contributing factors in the spread of AMR (Enshaie et al., 2025; Alem et al., 2025). In addition, AMR can increase and its management can be complicated by armed conflict where water and sanitation access break down, hygiene is compromised and the healthcare access can be further complicated by the destruction of the public healthcare system in the war jurisdiction (Ebied, 2025). The armed conflicts can itself be a catalyst increase in the resistance rate of the clinical microbial isolates. Qamar et al. (2022) reported that there was a 40 % increase in the resistance to amikacin, a 35 % increase in the resistance to doxycycline, and a 68 % increase in the rate of resistance to gentamycin in clinical isolated strains from patients before and after the Great March of Return in Gaza. Armed conflicts are currently raging in Eastern Europe and the Middle East, potentially indicating the likely hotspots of AMR increases.

In the 21st century, public healthcare systems can also experience an outbreak which is caused by a resistant pathogen strain, which is unfamiliar to the healthcare staff there. Unusual strains can include known but unfamiliar infectious disease such as the following examples. Strains of *Bacillus anthracis* are the causative agents of anthrax, and they remain a challenge as a biological hazard to this day (Alam et al., 2022). Accidental releases of anthrax spores from melting permafrost due to the human included-climate change have led to recent outbreaks of anthrax as a human disease in Siberia, Russia (Ezhova et al., 2021). At the same time, the human understanding of the anthrax microbiology and epidemiology has been exploited for terrorist attacks in the

USA, but also reactive measures have been taken to minimise further outbreaks and loss of life (Hughes and Gerberding, 2002). Humans have developed vaccines and antibiotic therapies for the treatment of anthrax (NICD, 2018). However, *Bacillus anthracis* is not a common pathogen in non-agricultural areas, and terrorist attacks are not a common occurrence in the most parts of the world. If a healthcare worker would see a case of anthrax they might struggle to diagnose the disease due to lack of knowledge about *Bacillus anthracis* and the clinical symptoms of relevant infections in human and animals. It is also possible for the healthcare worker to be unable to deal with the anthrax due to lack of diagnostic tools or therapeutic agents. Time pressure due to large number of patients increasing during wars and similar events, e.g. disasters, or stock outs of medicines or lack of resources can cause further problems for the public healthcare system to deal with AMR.

Scope of the current study

Against the above-mentioned background, the current narrative bioethical review seeks to conduct an assessment of global healthcare landscape of AMR management, and its links to South Africa. The narrative bioethical review will examine whether existing mechanisms can or cannot provide a functional foundation for the understanding of the extent of AMR as a threat to public health globally, regionally and in a specific country…namely South Africa. The authors will achieve the objectives of the study by using the format of a narrative bioethical review, which will be combined with bioethical analysis using the concept of the *utilitarian qubit*. In this narrative bioethical review, the methodology will be that of a narrative review, and it will be aimed at examining the policy tools, communication and data exchange platforms at strategic level (global and regional level of public healthcare systems with specific focus on policy adoption, healthcare system creation and maintenance), operational level (national state and provincial/state level of public healthcare systems and resource allocation, as well as information and knowledge sharing), and the tactical level of public healthcare systems (primary and local healthcare facilities, and in dealing with specific AMR-related outbreaks, epidemics, etc.). The overall aim of the current study will be to understand how current systems respond to and deal with AMR as a public health challenge and a biological hazard, and where the gaps in AMR management exist. The authors will attempt to outline how a holistic understanding of how all these tools allow humanity to understand the threats and risk from AMR, their development over time and the efficiency of the public health countermeasures.

Methodological approach

Outbreaks of infectious diseases due to drug-resistant pathogens, like the ones mentioned in the Introduction section, have been identified by humans due to the accumulation of scientific knowledge about pathogens and biological hazards over the

last two centuries or so. In addition, there have been numerous historical accounts of pandemics and disasters that have been linked to infectious diseases. The ability to identify and treat infectious disease outbreaks from biological hazards are an expression of the knowledge about the fundamental reality of human existence by *Homo sapiens* (Iheanetu et al., 2023; Msimang and Tandlich, 2025). It is also the manifestation of the use of it at the boundary between situational and fundamental reality of human existence for the currently living humans (Iheanetu et al., 2023; Msimang and Tandlich, 2025). On the other hand, human knowledge about the nature of fundamental aspects of life and the human environment have reached a point in time, where humans have the ability to exploit this knowledge to change the environment which they live in, and to exploit it for their benefit in improving their health. This has manifested with the production and regulatory approval, the use in human medicine of antimicrobial therapeutic agents. Humanity has developed and used some tools, based on this understanding, to manage and making the biological hazard impacts tolerable, e.g. through the ability general treatment of infectious disease, through the recent adoption of the Biological Weapons Convention of 1972 and the recent Pandemic Agreement (Chapman et al., 2025).

In spite of this, the biological hazards continued to cause disasters and extraordinary situations, which are super-wicked problems such as the COVID19 pandemic (Brown et al., 2024). However, AMR is a slow-emerging disaster (Viens and Littman, 2015), and so its management will have a significant temporal component. The solutions to AMR as a slow-emerging disaster are complex, the cause-and-effect relationships are often not completely known, and the actions to mitigate harms must nonetheless happen quickly while this uncertainty persists. As a result, impacts of AMR as a biological hazard on humanity...decision-making during a disaster will suffer from a finite level of inherent uncertainty. Disaster, where biological hazards interact with human activities and societies, can result in variety of outcomes in relation to AMR. Such outcomes will be influenced by the pre-disaster AMR settings in a given jurisdiction, the functioning or lack thereof of the public healthcare systems (monitoring for resistant pathogen strains, availability of the standardised prescribing and treatment guidelines, the availability of essential antimicrobials and antimicrobial medicines in general), appropriate and constantly updated training and knowledge sharing between the international and academic experts, and the frontline/public healthcare staff who work with patients. These are results of strategic and operational level decision-making based on the up-to-date knowledge and understanding of fundamental and situational (lived-in) reality of human existence, and its influence by AMR. Strategic decision-making will be the level of policy and law adoption, while operational level of decision-making will be concerned with the budget allocation to fulfil the strategic objectives for the tackling of AMR and AMR management. In a disaster due to AMR, incident management and tactical decision-making will make a big difference. Incident and tactical decisions will include those on the ground in the

actual AMR-infectious disease outbreak, which can precipitate into a local disaster, or which can negatively impact human wellbeing and health in a given jurisdiction. Disaster will be an outbreak or epidemic due to a resistant pathogen where prevention of loss of life is complicated. Finally, constant education and cooperation of the patients, to whom antimicrobial regimens are prescribed, are also important in AMR management and disaster outcomes determination. This last point stretches across both pre-disaster AMR and in-disaster, and post-outbreak decision-making and AMR landscape in a given jurisdiction.

AMR is the result of fighting infectious diseases with resistance and the overuse of the relevant medicines which leads to the negative feedback loop on human health and human wellbeing. In addition, the transfer of the AMR-causing genetic elements through the environment between variety of microorganisms and potential human pathogens links the entire socio-ecological system through AMR. Positive actions to heal disease and to reduce human suffering, as well as the animal suffering in some cases, leads to decrease the pain in the socio-ecological systems. Healing provides pleasure and eliminates or suppresses pain of human and parts of the socio-ecological systems. However, the feedback loop and the AMR that develops due to overuse of antimicrobials causes pain against humans. In the presence of the AMR and during their current existence, humanity and the socio-ecological systems that *Homo sapiens/Homo deus* is part of, exist in a permanent state of the *utilitarian qubit* (Iheanetu et al., 2023). This is a state of existence where the pain and pleasure both concurrently control or strongly influence the human living experience, but it is impossible to distinguish whether pain or pleasure is the dominant driver (Iheanetu et al., 2023). Boundary between the fundamental and situational reality of human existence will thus be experienced by humanity and the socio-ecological systems in the state of *utilitarian qubit*, where suffering or non-optimum status of wellbeing will be the norm due to the pain/pleasure as drivers uncertainty in relation to human existence. For AMR, this will be due to the humans living in the presence of pathogen that cause infectious diseases and which can thus cause pain and suffering. However, the treatment with antimicrobials causes pleasure or healing at least temporarily. The pain can re-established when *Homo sapiens/Homo deus* is impacted by the AMR feedback loop. AMR management at the strategic, operational and tactical level of decision-making need to take the *utilitarian qubit* into account.

For effective decision-making, it is necessary to decipher the impacts of biological hazards such as AMR on humans in a given place, space and time…but also over periods of time to assess the influence and success/failure of decision-making processes in public health. It is therefore necessary and to gather, evaluate and draw conclusions based data on the actual status of the AMR landscape in a given jurisdiction. Practically, this means that one has to gain understanding of the pre-AMR-outbreak

conditions and capacity of public healthcare system to deal with an outbreak due to a resistant pathogen, as stated above. It is also pertinent to collect data on the actual on-the-ground status of the healthcare workers in the public health system and their ability to deal with the AMR and possible outbreaks, epidemics or disasters. Data on these aspects must be the basis to gain at least some understanding of the human existence in the presence of AMR and in the concurrent status of the *utilitarian qubit*. A qubit is normally a system which can have a value of 0 or 1, or both at the same time. Iheanetu et al. (2023) stated that the uncertainty about the degree to which pain, and to which pleasure, determine human experience in the Age of Anthropocene and the Great Acceleration (as further developed by Msimang and Tandlich, 2025)…lead to the *utilitarian qubit* of human existence always having an unknown value between 0 (pain) and 1 (pleasure). This is based on the impossibility to identify that value at any point in time due to multiple uncertainty impacting human existence. That originally included uncertainty of the human existence in the context of the COVID19 pandemic, the impacts of the concurrent changing nature of human existence through the increasing significance of social media dimension of one's self, and the background of ongoing climate change challenges and its health impacts on humans (Iheanetu et al., 2023). In this current article, the *utilitarian qubit* will be used to assess the human existence in the presence of AMR. The values of *utilitarian qubit* will again have similar values, and the actual data will paint a particular picture.

The cause-and-effect of infectious disease outbreaks can be straight forward, and the causative agent of a specific outbreak can be easily diagnosed. This is most likely to occur when the public health systems function at optimum levels, when all components of AMR detection and management are in place, and when the personnel are optimally equipped with resources and knowledge to play their respective roles in the AMR management. All three levels of planning and decision-making, i.e. strategic, operational and tactical, are likely executed under optimum conditions. On the other hand, complicated cause and effect relationships for the AMR-related infectious diseases can occur due to the unpredictable exposure routes, lack of necessary resources and knowledge in the public healthcare system to effectively prevent human suffering and to mitigate the outcomes of the AMR-related biological hazards (Brown et al., 2024). Here, a reactionary or reverse decision-making and tactical level of it will play a crucial role. To distinguish between the predictable AMR outcomes, and those that could indicate that AMR is a super-wicked problem in a given jurisdiction, it is necessary that the public healthcare system has certain features. Firstly, there must be sharing of information, best practices, and resources about the latest features of the AMR landscape globally, nationally and in the local settings. Such information should be shared at the strategic level of planning, and policy making. Resulting information and decisions, which are driven by the latest data on the AMR landscape, should then drive the actions to tackle AMR at the operational and tactical level, i.e. at

levels of regions and local jurisdictions responsible for public health. Secondly, policies and legislative tools should create system of indicator and quantitative data collection, processing and evaluation to inform the decision at the strategic, operational and tactical level of AMR management. Thirdly, the experiences of the stakeholders in AMR management, qualitative in nature should be collected and used to supplement the decision-making based on the quantitative data. These efforts must be ongoing, and they must take place on an ongoing basis at international, regional and national, as well as at the sub-national level of government.

It is against this background that the following Results and Discussion section will examine the completeness of AMR management in public healthcare systems at the three level of decision-making and healthcare system functioning. Availability of data, resources and knowledge sharing will be examined to establish whether pain (human suffering) or pleasure (successful dealing with biological hazards due to AMR and the treatment of outbreaks and epidemics) is taking place. This will be done for the global landscape, several regions of the globe and for AMR landscape in South Africa. In this way, it should be possible to determine the reality of the human existence in the state of *utilitarian qubit* in relation to AMR in the 21st century. It might also be possible to identify possible solutions to address the gaps in public health systems' capacity to deal with AMR. Remedial and coping strategies will be focused on data exchange, information and knowledge sharing, and the feedback loops among the strategic, operational and tactical decision-making levels. If the narrative bioethical review methodology and combination with bioethical analysis is successful then it might be possible to get an idea about the trends in asymptotic or limiting values of the *utilitarian qubit*, i.e. it should be possible to understand whether AMR management is driven more by pain, pleasure or both.

Results and Discussion

Global Strategies for Combatting Antimicrobial Resistance

There have been many global strategies for combatting or tackling AMR, many initiatives have been attempted or are currently in place/being implemented. In May 2015, the 68th World Health Assembly (WHA) implemented a *Global Action Plan on AMR* which set out five strategic objectives (WHO, 2022h):

- To improve awareness and understanding of AMR;
- To strengthen knowledge through surveillance and research;
- To reduce the incidence of infection;
- To optimize the use of antimicrobial agents; and
- Develop the economic case for sustainable investment that takes account of the needs of all countries, and increase investment in new medicines, diagnostic tools, vaccines, and other interventions.

The WHA advocated that all Member States adopt the *Global Action Plan on AMR* and have national action plans in place by 2017. In order to help nations formulate and align their plans with the *Global Action Plan on AMR*, a manual was developed which was primarily dependent on the resources available in each country (Goff et al., 2017; WHO, 2015b). As of November 2022, 170 countries have finalized their National Action Plan which align with the objectives of the *Global Action Plan on AMR*, and 38 countries are in the process of developing their national action plans (WHO, 2022h). The COVID-19 pandemic has made it more crucial than ever to carry out interventions at the cornerstone of national actions plans on AMR, including health systems strengthening, laboratory strengthening, infection prevention and control, water, sanitation, and hygiene (WASH), and AMS (WHO, 2021a). This indicates efforts at the strategic level of international planning to tackle AMR, but more countries should be involved.

In 2015, WHO launched the first *Global Antimicrobial Resistance and Use Surveillance System* (GLASS) which initially offered surveillance of AMR in bacteria that cause common human infections. GLASS has now broadened its focus to include surveillance of antimicrobial consumption, invasive fungal infections, and a 'One Health' surveillance model that is pertinent to human health. As of December 2022, 126 countries, territories and areas are participating and providing data to GLASS (WHO, 2022k). In 2016, WHO partnered with Drugs for Neglected Diseases Initiative to create the Global Antibiotic Research and Development Partnership (GARDP), a crucial aspect of WHO's *Global Action Plan on AMR*, to expedite the development of new medicines for drug-resistant infections (WHO, 2023a, 2023c). Furthermore, in 2017, WHO published a global priority pathogens list for which antibiotics are urgently required (WHO, 2017a, 2023a). As a result, it can be said that the monitoring mechanisms and information/knowledge exchange about AMR are underway, i.e. at the strategic level about 65 % of all 193 UN countries are involved. Gaps exist, but progress is clear and the trend seems to be towards decreasing human and socio-ecological systems' suffering.

At the 71st United Nations General Assembly in 2016, the Political Declaration of the High-Level Meeting on AMR recognised that AMR challenges the attainment of the 2030 Agenda. Global leaders pledged to

> *"strengthen regulation, improve knowledge and awareness on antimicrobials, promote best practices, and foster innovative approaches using alternatives to antimicrobials and new technologies for diagnosis and vaccines"* (UN, 2016; WHO, 2016b).

AMR was the fourth health issue to ever be discussed at the United Nations General Assembly, following after HIV/AIDS, non-communicable diseases, and Ebola Viral Disease (ReAct, 2021; United Nations, 2016), showing the importance of tackling this major public health threat. The Declaration recognised the need for a continued 'One Health' approach and mandated the establishment of the Ad Hoc United Nations Interagency Coordination Group (IACG) co-chaired by the Executive Office of the

Secretary-General and WHO (ReAct, 2021; United Nations, 2016). AMR is viewed as a 'One Health' problem as microorganisms can infect both humans and animals and can thrive in the natural environment (Mitchell et al., 2022; WHO, 2019b). For this reason, strong sector-specific responses and multisectoral collaboration are both needed to combat AMR (WHO, 2022e). Strategic level of planning and decision-making has been receiving continuous attention, focus, and commitment at the international level. Focus on the 'One Health' approach also indicates that AMR impacts and solutions are being driven by considerations of the entire socio-ecological systems.

In support of implementing the fourth objective of the *Global Action Plan on AMR* to optimize the use of antimicrobials, WHO launched a practical toolkit on *Antimicrobial stewardship programmes in health-care facilities in low- and middle-income countries* in 2019, which offers practical guidance, evidence-based policy recommendations, and tailored country-level support towards implementing AMS programmes at the national and healthcare facility level in LMICs (WHO, 2019d, 2023d). Holistic strategic and operational decision-making tools are being developed and made available to AMR stakeholders and public healthcare systems in LMICs, places and countries that face a continuously increasing threat from AMR. The focus from the previous strategic level of decision-making seems to be filtering down to the operational level of decision-making and AMR management.

There are increasingly more calls for strengthened and formal international governance frameworks to coordinate the response to AMR (WHO, 2023b). The Tripartite formed by the Food and Agriculture Organization of the United Nations (FAO), the World Organisation for Animal Health (OIE), and the WHO promotes the responsible use of antimicrobials in humans, animals and plants through the 'One Health' approach (WHO, 2021i, 2023b). In 2019, the IACG submitted its report to the Secretary-General of the United Nations which included five target areas of country progress, innovation, collaboration, financing and governance (WHO, 2019b, 2020, 2023b). The IACG further recommended the formation of the Global Leaders Group on AMR, the Independent Panel on Evidence for Action against AMR and a Partnership Platform (WHO, 2019b, 2020). This indicates a structured and scientifically driven, as well as continuously updated, approach to strategic level of AMR decision-making and management.

The AMR Multi-Partner Trust Fund (MPTF), established on 15 August 2019, uses strategic collaboration, sustainable sources of funding, and solutions centred on the SDGs to tackle AMR and support 'One Health' National Action Plans. As of 2020, 10 million USD has been approved for initiatives in 10 countries; four worldwide programmes on surveillance, legal frameworks, and monitoring and evaluation have been approved; and 80 community organisations have implemented rural plans. (UNDP, 2020). Furthermore, in response to the recommendations from the IACG

on AMR, the Tripartite, inclusive of WHO, FAO and OIE, announced the establishment of the 'One Health' Global Leaders Group on AMR in November 2020 to advocate for urgent action to tackle AMR using the 'One Health' approach (WHO, 2021a). The Global Leaders Group on AMR is working on six priority areas to increase political momentum, leadership and AMR action (Global Leaders Group on Antimicrobial Resistance, 2023). The overlap between strategic and operational decision-making regional levels is indicated here. Data collection, evaluation and sharing for the operational decision-making is being implemented. Particular challenges and up-to-date proactive management can also be seen from priority identification.

The importance of managing AMR through behaviour change was emphasized amongst experts at the Uppsala Health Summit held virtually in March 2021 (WHO, 2021b). Following this event, a Call to Action to combat AMR was delivered and signed by 109 Member States at a High-Level Dialogue on AMR convened by the President of the UN General Assembly in April 2021 (WHO, 2021b). In 2021, WHO then launched *The WHO Essential Medicines List Antibiotic Book* (WHO, 2021h) to provide guidance on the choice of antibiotic, dose, route of administration and duration, in line with the *WHO Model List of Essential Medicines* (WHO, 2021f) and the AWaRe classification of antibiotics (WHO, 2021e). In the same year, WHO launched a new toolkit on *Strengthening infection prevention and control in primary care* (WHO, 2021d, 2021j). In May 2022, WHO published its first-ever *Global Report on Infection, Prevention and Control* which analysed the implementation of IPC programmes globally and highlighted the available resources and strategies for nations (WHO, 2022e). In addition, the *Framework and Toolkit for Infection Prevention and Control in Outbreak Preparedness, Readiness and Response at the Health Care Facility Level* was released by WHO in 2022. The framework, with a special focus on AMR control, is directed at stakeholders in healthcare facilities and offers the overarching concepts, methodology, and resources in each step of outbreak management (WHO, 2022a, 2022g).

Bertagnolio et al. (2024) documented this further by reviewing the AMR-focused research priorities which have been centred around tackling AMR in bacterial and fungal pathogens. Between 2016 and 2023, the World Health Organisation (WHO) has reported that the number of countries that reported data to the GLASS programme increased from just under 30 to mor than 90 (WHO, 2025a, Figure 1 in Summary). Primary threats to the public health of humans have been posed by Gram-negative bacteria and majority of the uneven distribution of the AMR occurrence is carried by LMICs (WHO, 2025a, Summary). In addition, the median percentage of the AMR has been reported to range from 9.1 to 31.1 % of all pathogen-antibiotic combination with the maximum occurrence reported from the South East Asia region of the WHO (WHO, 2025a, Figure 2 in Summary). In order to monitor AMR, it is necessary to monitor the spread and genotypes of pathogens that cause infectious diseases and pathogen

which can obtain AMR elements in their genomes. During the COVID19 pandemic, several such programmes have been operationalised, and have gained global reach. Information exchange about coronavirus nucleic acid sequences have been shared, with some disparities becoming apparent among the developing and developed countries (Brito et al., 2022). There are also other online databases for the antimicrobial genetic sequence information, e.g. the Comprehensive Antibiotic Resistance Database which is operated by the McMaster University in Canada (McMaster, undated). Improvements in the collaboration and reporting on AMR specifics from various regions around the world are thus increasing. Ability to track and operationalise information at the regional and country level of decision-making will be strongly improved using these systems.

This subsection indicates that political commitment and policy tools have been developed to coordinate the efforts to tackle AMR. It is clear that there is a push and ongoing and increasing coherence in the view of AMR as a public health threat. This is matched by attempts, which have been successful to some extent, to standardise policy and reporting/monitoring tools to support and ultimately to tackle AMR at international and regional level. These tools are internationally-driven and nationally adopted and contributed to, i.e. WHO and the national governments of many states work collaboratively on tackling AMR as a public health threat. They do this by sharing data and signing up to the WHO programmes which are specifically designed to collect data on AMR occurrence and nature, and to use these data as a basis to develop universally-adoptable approaches to resolve the AMR, its triggers and the impacts. This proves awareness and the desire, the drive to resolve AMR as a public health threat at the global level of engagement. Integrated view of AMR impacts on the entire socio-ecological system is visible from various policy and strategic level decision-making initiatives. Operational basis for the best available methods and latest scientific knowledge, classification of the antimicrobial agents is available, but more uptake by UN member countries is necessary for specific programmes. Based on this information, the *utilitarian qubit* of human existence in relation to AMR will have both values of 0 (pain) and 1 (pleasure) at the strategic and operational level decision-making. Some uncertainty in the data will exist due to the incomplete participation of all UN states in the AMR-tackling initiatives and programme that have been mentioned in this subsection of the narrative bioethical review. What is necessary to examine next is the AMR management, threat perception and tackling at the more regional level, and specifically in regions where the challenge is of the largest significance. This is examined in the next subsection of the narrative bioethical review for developing countries.

Antimicrobial Resistance in Developing Countries

Some of the major diseases significantly affected by AMR, especially in developing countries, include HIV/AIDS, tuberculosis (TB), pneumonia, and malaria, as these diseases are becoming harder to treat due to antimicrobials becoming less effective (Department of Health Republic of South Africa, 2014a, 2014b, 2018a; WHO, 2018e). Healthcare facilities in LMICs face additional challenges, such as limited infrastructure, high patient load, understaffing, and a lack of education and training on AMR and AMS programmes (Kakkar et al., 2020). The Indian Council of Medical Research conducted a survey amongst 20 tertiary level healthcare institutes in 2013. Their study found that only 30 % of the institutes had AMS implementation strategies, only 40 % had AMS programme documents, 65 % had AMS prescription guidelines, and 75 % had infection control guidelines (Walia et al., 2015). This indicates that strategic level policies and operational level decision-making, and resource allocation are likely not sufficient to tackle AMR in all cases and effectively.

It is essential to understand current practices across all healthcare systems in order to promote a stewardship framework that is appropriate to the context of the healthcare system and that is culturally sensitive, flexible, and dynamic enough to meet the needs of the targeted population (Howard et al., 2015). Sub-Saharan Africa has the highest AMR-related mortality rate globally, at 99 per 100,000 population, well above the prior worldwide projections of 700,000 AMR deaths annually (WHO, 2022i, 2022j). The World Bank warns that AMR may cause developing countries in Africa to lose up to 5 % of their GDP. Accordingly, the financial cost of AMR would be greater than the financial crisis of 2008 (World Bank, 2016; WHO, 2021g). Killer infections like TB have developed resistance to the life-saving antibiotics. A once-effective therapy for malaria, which kills 3,000 children in Africa daily, is losing its efficacy, which shows the high risk of losing these life-saving medications if we do not combat AMR (WHO, 2021g). This highlights the current significance of the biological hazards in the Sub-Saharan African countries and AMR. There is also a potential for public healthcare systems to face super-wicked problems if an outbreak due a resistant pathogen strain was to occur. Increased strategic and operational planning at the regional and country level are necessary. These must be aligned with operational and tactical actions and steps to tackle AMR.

Infectious diseases continue to be a major burden in Africa. AMR is a rising problem in Africa for numerous reasons, such as poor healthcare systems, HIV and malnutrition-related infection risks, and a high burden of disease, and the overuse of antibiotics only serves to exacerbate this problem. Despite AMR being a major issue, AMR has not yet been prioritized sufficiently for study owing to conflicting priorities (South African Medical Research Council & GARDP, 2016). There has historically been a lack of participation from African countries in global action plan campaigns to combat AMR, which is problematic as it is a severe threat to public health (WHO, 2015c). It is also

important to note that none of the 26 WHO Collaborating Centres on AMR, antimicrobial use, and infection prevention are in Africa. Moreover, many other organisations and partners active in antimicrobial surveillance, resistance containment, and rational medicine use are not functional in Africa (WHO, 2018a). Parts of the public healthcare systems are thus not functional in African LMICs, which can contribute to increased suffering of humans when outbreak of infectious disease occur due to resistant pathogens. This indicates that *utilitarian qubit* will likely move towards 0 or pain value in many African countries. Partly, this seems to be the result of insignificant threat perception in the LMICs on the African continent, and across its individual regions.

To address this, awareness must be raised, and research funding should be increased in order to produce better data to inform advocacy and prescribing, which will result in the rational use of antibiotics and improved healthcare systems. It is crucial to develop new, rapid point-of-care tests that can distinguish between bacterial and viral infections. There are still major gaps in training, human resources, and healthcare infrastructure, and such, the challenges of AMR should be seen as an opportunity for capacity building, appropriate task shifting, and strengthening healthcare systems (South African Medical Research Council & GARDP, 2016). WHO recommends task shifting as one of the strategies to strengthen and increase health workforce (WHO, 2008). Task shifting entails moving specific tasks from highly qualified healthcare professionals (who are fewer in number) to less qualified health workers (who are greater in number) to improve efficiency of available health human resources (Abrokwa et al., 2022; Orkin et al., 2021). This, with sufficient resource allocation, education of the community healthcare workers and oversight from formal healthcare workers (Sharma et al., 2025), would provide a platform and a mechanism to strengthen the tactical level of decision-making in AMR management.

A study in Ghana proved that chronic illnesses were managed successfully through task shifting at the community level (Ahadzi & Beasley, 2023). Another study highlighted that task shifting to CHWs in particular can reduce costs, improve community outreach, and efficiently scale up essential treatments (Mundeva et al., 2018). Such pilot programme can be used and re-designed for the specifics of management of infectious diseases and AMR. Training of frontline workers must be prioritised at the operational level of AMR-related decision-making. At the same time, knowledge sharing with lay healthcare workers should be strengthened (Sharma et al., 2025). Information about the tactical environment, i.e. collection of data on the actual landscape and challenges in AMR management at the level of public healthcare systems which is closest to the patient, will need to be collected, evaluated and use as a foundation for the relevant actions and decision-making. This would be a tactical level of decision-making and being closets to the patients and the threat perception by frontline workers would be the best tailored to the local public healthcare system conditions and AMR landscape.

In this way, the resource deployment and use in interventions to tackle AMR could be optimised. By the same token, the human existence in the state of *utilitarian qubit* could be pushed towards 1 (pleasure or lack of suffering and pain in patients treated for the AMR-related infectious diseases).

Set of international surveys reported that only 14 % hospitals in Africa have AMS programmes in place, compared to 58 % globally (Huttner et al., 2014; Kakkar et al., 2020). More recent literature reviews indicate that resource limitations continued to be a major problem with successful running of AMS programmes between 2010 and 2023 (Ehsan, 2025). Surveys in this context are important to continuously increase the awareness and to have up to date data on the AMR development and management systems (Huttner et al., 2019; Klein et al., 2021). Personal dimension and personal ways to express the health impacts will be critical to amend the official public health data collection, e.g. as shown by Latif (2020). Such efforts contribute to sustaining the fight against AMR (World Bank & WHO, 2022). A systematic literature review looked at the implementation of AMS programmes in African countries, including South Africa. The findings of the review showed that AMS programmes improve antibiotic guidelines, decrease antibiotic consumption, increase compliance and adherence, shorten the treatment duration and lower AMR. The review illustrates that despite numerous challenges, African healthcare facilities with limited specialized resources can still effectively implement AMS programmes (Akpan et al., 2020). The limited number of studies identified in this narrative bioethical review highlight the extreme lack of data available on AMS programmes in Africa (Akpan et al., 2020; Cox et al., 2017; Kapatsa et al., 2025; Van Dijck et al., 2018; Wilkinson et al., 2019). This means that best practices and resource allocation methods exist to facilitate successful operational and tactical decision-making. However, it has to be said that the limited data seem to indicate that the current status of many African public healthcare systems is not conducive to the necessary decrease of human suffering due to AMR, and so *utilitarian qubit* will most likely take on the value of 0 (pain).

WHO stated that it is crucial to tackle AMR by strengthening healthcare systems in order to accomplish Universal Health Coverage globally. In response to the WHO *Global Action Plan on AMR*, WHO has been assisting Nigeria to strengthen surveillance in 10 sentinel sites and AMR stewardship in three tertiary institutions (WHO, 2022b). The Government of Zimbabwe identified numerous actions in its National Development Strategy 2021-2025 as a first step in addressing AMR, which includes increasing access to essential medications, strengthening regulatory measures, and promoting the rational use of medications. The United Nations Country Team has prioritized combating the spread of AMR in Zimbabwe's *United Nations Sustainable Development Cooperation Framework 2021–2026* in order to assist the Government of Zimbabwe in achieving its goals (WHO, 2022d). Additionally, Mauritius is one of three countries who took part in the WHO AMR consumption monitoring and pilot survey (WHO, 2018d).

Moreover, Ethiopia launched the WHO African Region's first sector-specific plan on AMR prevention and control during WAAW 2022 (WHO, 2022k). Strategic level decision-making and initiatives must therefore be matched with the lower level operational and tactical supplements in the fight against AMR.

To achieve this, some African countries are facilitating activities and campaigns to combat AMR and increase awareness (Sharma et al., 2025). In order to increase awareness on AMR and promote behaviour change amongst the public, healthcare workers and policymakers, the WHO Regional Office for Africa launched the RESIST AMR campaign (WHO, 2021b). Furthermore, the WHO Regional Office for Africa held its first AMR Education and Awareness Regional Webinar Series from May to December 2022, providing a forum for countries to exchange best practices, challenges, knowledge and skills with regards to strategies for raising awareness on AMR (WHO, 2022f). These need to be coupled with ongoing collection of the data on the local drivers of the AMR development, and the creation of local information and health promotion tools to combat increase in AMR prevalence (Sharma et al., 2025). These localised effort should be shared across the African continent to improve and strengthen operational decision-making and AMR management, with filtering down to the tactical level. Such sharing strategies would facilitate the asymptotic value of human existence with AMR towards 1 (pleasure and not suffering among patients in relation to the AMR-related outbreak of infectious disease due to a resistant pathogen).

Despite the above examples of African countries working towards combating AMR, it is important to note that no data from WHO AMR newsletters referred to AMS programmes and activities being conducted in countries with large economic power, where many migrants are moving to and where a lot of biomedical research is taking place. Example of such a country is South Africa, where the lack of newsletter coverage has been going on for significant periods of time in recent years (WHO, 2021a, 2021b, 2021c, 2021j, 2022c, 2022f, 2022g). This therefore highlights the inadequate, or rather inconsistent strategic actions and inactivity and emphasizes the urgency of implementing AMR-related activities and programmes in the nation. Some improvements but also challenges continue to be reported recently from South Africa (Sharma et al., 2025). However, these are exception rather than signs of necessary trend in shifting the *utilitarian qubit* away from 0 (pain) towards 1 (pleasure, curing and eliminating suffering of patients in relation to the AMR-related outbreak of infectious disease due to a resistant pathogen).

Based on the information from this section of the narrative bioethical review, it is clear that there are efforts, programmes and even policies being implemented in developing countries to tackle AMR. However, gaps exist in the monitoring of the extent of AMR occurrence, and more efforts need to be implemented in the areas of monitoring and optimising antimicrobial medicines use across the healthcare systems

in developing countries, e.g. on the African continent. It is necessary to increase the data collection and reporting on AMR spread and threat significance in public healthcare system in Africa. From a prevention and the public health emergency management point of view, it is necessary to increase our understanding of the size of the threat from AMR to the population's health. The size of the threat and risk and the population's exposure/contact with the AMR-causative microbial agents must be further improved. Based on this sub-section, the *utilitarian qubit* for human health in relation to AMR will take on the asymptotic value close to 0 (pain) due limitations in the public healthcare system. More information about the tactical level can help identify the best practices which have been implemented in the national and sub-national healthcare systems in LMICs. This could provide candidate programmes and the best practices for possible improvements in the operational level of AMR management, and potentially even inform the policy changes to be implemented at the strategic level of AMR management in LMICs and globally. In the next subsection, more detailed examination of the national and sub-national (tactical) level of decision-making and AMR management is analysed for South Africa.

Antimicrobial Resistance in South Africa

Based on WHO's resolution to combat AMR, South Africa made a commitment to develop a National Action Plan on AMR (Department of Health Republic of South Africa, 2018a). The Federation of Infectious Diseases Societies of Southern Africa (FIDSSA) was formed to address infectious diseases challenges as biological hazards (among other tasks), by publishing guidelines on the appropriate treatment of infectious diseases, as well as infection control practices. FIDSSA served as the umbrella organization for the formation of the South African Antibiotic Stewardship Programme (SAASP). SAASP aims to promote rational antibiotic prescribing, education, and collaboration with the National Department of Health on the AMR response. Advocacy by SAASP and WHO encouraging Member States to develop a National Action Plan led to the development of the *Antimicrobial Resistance National Strategic Framework, 2014-2024*, which highlights the importance of strategic enablers to manage AMR. The strategic enablers include: legislation; education through sustained public health campaigns; communication through partnerships with the media; and research (Department of Health Republic of South Africa, 2014a). The three pillars of the National Strategy Framework for AMR are AMS, surveillance and reporting, and better infection prevention and control. For the 2014-2019 Strategic Framework, the strategic objectives were as follows (NDOH, 2015)

"1. Strengthen, coordinate and institutionalize interdisciplinary efforts through national, provincial and health establishment level governance structures;

2. Improve the appropriate use of diagnostics to identify pathogens and guide treatment by promoting appropriate and timely selection and collection of specimens, accurate and timely testing, accurate and timely reporting of results;

3. Optimise surveillance and early detection of AMR for reporting local, regional, and national resistance patterns to optimise empiric and targeted antibiotic choice;

4. Enhance infection prevention and control of the spread of resistant microbes to patients in health care settings, focusing on improvement in hand hygiene and the identification and isolation of patients with resistant organisms. Prevent infections through wide reaching vaccination programmes;

5. Promote appropriate use of antimicrobials in human and animal health through antimicrobial stewardship".

As it can be seen the planning and strategic decision-making to tackle AMR in South Africa is based on achieving holistic objectives and approach. The holistic 'One Health Approach' is based on updating the National Health no. 61 of 2003 with the necessary guidelines, and the updating of the Stock Remedies legislation to minimise the use of antibiotics in livestock husbandry (NDOH, 2015). Coordination has been put in place between the South African National Departments of Health and Agriculture, Forestry and Fisheries (where veterinary medicine and legislation are housed at the national government level; NDOH/DAFF, 2017-2024). AMS and One Health approach, monitoring, communication and data exchange and continuous education and training for stakeholders is embedded in both documents. The schematic representation of AMR governance in South Africa is shown below in Figure 1. At the national government level, the Ministerial Advisory Committee on AMR was suggested as a hub for communication and exchange of data, and information. The structure and organogram of this committee can be seen in Figure 2 below.

Plans to improve current healthcare systems, educate the public and the workforce, encourage local research and development into medicines, diagnostics, and preventative measures serve as the foundation for these (Mendelson & Matsoso, 2017). A number of organisations are associated with these initiatives in South Africa, including the South African Society for Clinical Microbiology, Infectious Diseases Society of Southern Africa, and the National Surveillance Forum (FIDSSA, 2022). Therefore, strategic planning and basis for decision-making at this level are in place in South Africa. In addition, a partnership between South Africa, Kenya, Vietnam, and India, called the Global Antibiotic Resistance Partnership (GARP), was established. GARP-South Africa was launched in 2010, aimed at developing a multidisciplinary national task team which compiles information based on the strengths, weaknesses, and gaps in strategies used to combat AMR (Gelband, 2015). Furthermore, a three-year collaboration between researchers from South Africa and the UK is set to combat AMR by utilizing South Africa's rich biodiversity to hasten the development of new antibiotics. A global drug discovery network will also be established, with a focus on creating new drug candidates for WHO's priority pathogens which are most

commonly associated with AMR, and gonorrhoea, which is also a global AMR research priority (South African Medical Research Council, 2020).

Figure 1. Details of the strategic framework for AMR management in South Africa (extracted from NDOH/DAFF, 2017-2024, page 13; no copyright applies as far as authors could establish).

Yet, there were gaps and disparities in the healthcare system, and regions such as the Eastern Cape Province had been inadequately resourced health services. That had led to consistent lack of information on resistant strains and a limited availability of analytic facilities to distinguish between bacterial and viral infections (Department of Health Republic of South Africa, 2015-2024). The primary reason was primarily due to the limited or no access to laboratory systems, making it difficult to select appropriate antimicrobials based on culture and sensitivity profiling (Department of Health Republic of South Africa, 2015-2024; Okeke, 2016). There was also a lack of trained practitioners able to expand on the AMS programme in active institutions or in those without the programme (Department of Health Republic of South Africa, 2015-2024). Therefore, even if the strategic planning and actions are there to tackle AMR, any efforts will be potentially hampered at the operational and tactical level due to resource and skills shortages on the local/sub-national level of the South African public healthcare

system. This places South African population at substantial risk from the AMR and its public health consequences.

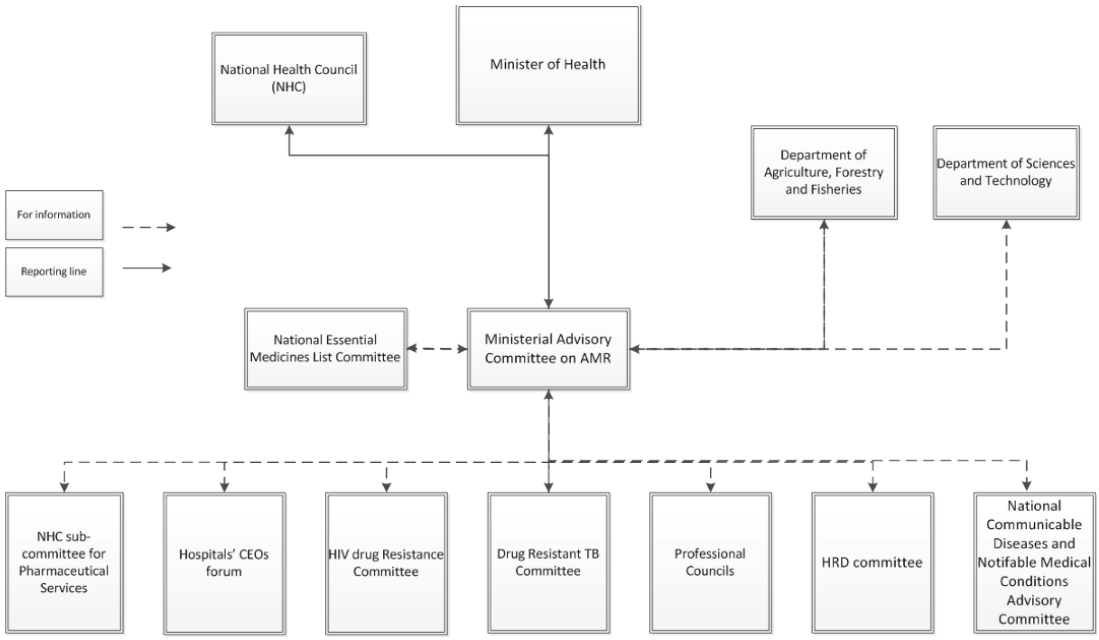


Figure 2. Organogram of communication and information exchange Ministerial Advisory Committee on AMR (extracted from NDOH, 2015, page 6; no copyright applies as far as authors could establish).

Moreover, South Africa, as one of the BRICS countries, has been identified as a major contributor to the global increase in antibiotic consumption. South Africa's usage of antibiotics is comparable to other BRICS countries but much greater than that in non-BRICS countries. The use of broad-spectrum antibiotics in South Africa is 1.3-3.3 times higher than in other BRICS countries and is 0.8 times higher than that in the UK or USA (Department of Health Republic of South Africa, 2018b). However, there is a paucity of detailed surveillance data on antibiotic consumption at the provincial, local, district and institutional levels (Chetty, 2021), with limited studies done at the local subdistrict level (Sharma et al., 2020).

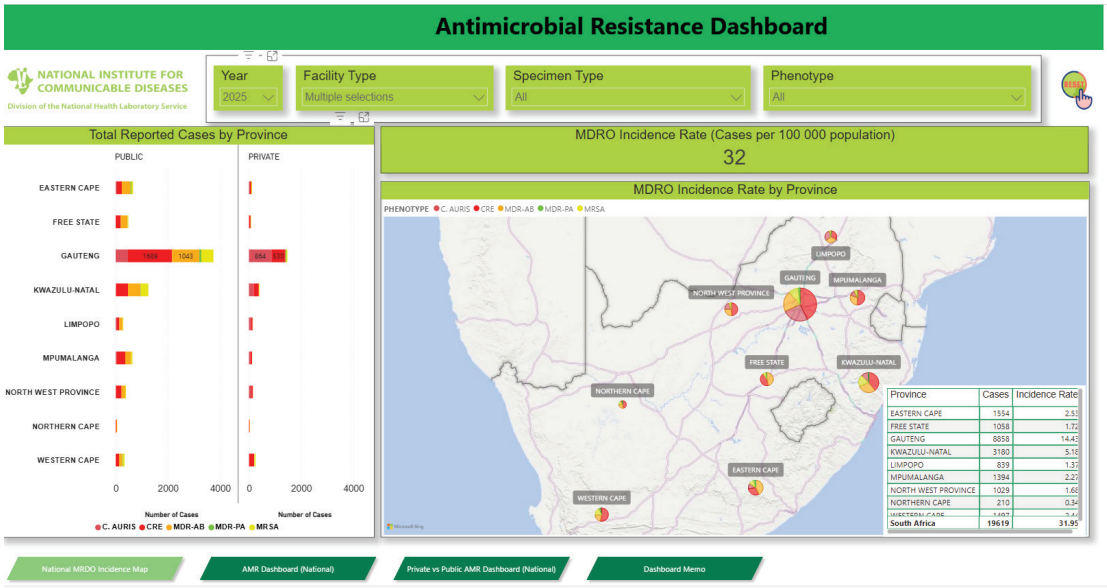
Many hospitals in the South African private and public healthcare sectors have engaged in some form of AMS programme activity, and the majority were straightforward quality improvement initiatives. Though hospitals in the private sector frequently carry out AMS programme activities, only a few hospitals in the public sector have effectively implemented AMS programmes (Boyles et al., 2013; Chetty et al., 2019; Junaid et al., 2018; Ramsamy et al., 2019). Another factor that limited the South African healthcare sector's capacity to properly manage an AMS programme was the lack of time and human resources (Chetty, 2021).

A mixed-phase study was conducted amongst 26 South African public sector healthcare facilities. Emerging themes showed that public healthcare facilities across South Africa are facing many challenges, particularly at entry level PHC facilities, where AMS programmes and activities are not fully implemented. These facilities lack diagnostics and surveillance data. Health campaigns are almost non-existent, and there is a lack of ongoing education for healthcare professionals, particularly for prescribers at the PHC level. Since PHC facilities serve as the majority of patients' first point of access to healthcare, it is crucial to address the challenges associated with enhancing antimicrobial prescription in order to minimize AMR (Engler et al., 2021). Inefficiencies in the AMS programmes will create challenges in the monitoring and tackling of AMR under local conditions. Therefore, the execution of AMR management at the tactical level of public health planning and service delivery will be problematic in the specific healthcare facilities in South Africa.

In recent years, several initiatives have been implemented to address the lack of microbiological laboratories and analytical facilities in some parts of South Africa. At the same time, many efforts were completed to align the strategic, operational and tactical level of AMR-related decision-making (see Figures 1 and 2 above for details). The National Institute for Communicable Diseases (NICD) launched the antimicrobial resistance dashboard, and this provides a variety of information, as shown in Figure 3 below (NICD, 2023-2025). The dashboard provides overall picture of AMR across South Africa incidence rate of resistance organisms per province (see Figure 3a for details), the susceptibility testing results per province and per medicine (see Figure 3b for details), and the monthly case load patterns (see Figure 3c for details). This tool provides holistic access to information for all stakeholders in the AMR landscape in South Africa for the time period from 2020 until 2025 (NICD, 2023-2025). Strategic planning and decision-making objectives are reflected in the practical action, and so the programme to tackle AMR are actively implemented by the South African government. It is also possible to allow the facilities that lack laboratory analysis of AMR, to use the surrogate NICD data to drive optimum AMR management. This further allows for the optimisation of operational and tactical tackling of AMR.

A pharmacist-driven AMS programme was implemented and assessed across 47 South African hospitals between October 2009 and September 2014. The study showed that healthcare facilities with inadequate knowledge and skill in the treatment of infectious diseases can achieve significant reduction in antimicrobial misuse by focusing on basic interventions and through the introduction of pharmacist-led AMS programmes (Brink et al., 2016).

a)


Antimicrobial Resistance Dashboard
NATIONAL INSTITUTE FOR COMMUNICABLE DISEASES
Division of the National Health Laboratory Service
Year
2025
Facility Type
Multiple selections
Specimen Type
All
Phenotype
All
Total Reported Cases by Province
PUBLIC
PRIVATE
EASTERN CAPE
FREE STATE
GAUTENG
KWAZULU-NATAL
LIMPOPO
MPUMALANGA
NORTH WEST PROVINCE
NORTHERN CAPE
WESTERN CAPE
0
2000
4000
Number of Cases
C. AURIS
CRE
MDR-AB
MDR-PA
MRSA
MDRO Incidence Rate (Cases per 100 000 population)
32
MDRO Incidence Rate by Province
PHENOTYPE
Province
Cases
Incidence Rate
South Africa
19619
31.95
National MRDO Incidence Map
AMR Dashboard (National)
Private vs Public AMR Dashboard (National)
Dashboard Memo

b)


NATIONAL INSTITUTE FOR COMMUNICABLE DISEASES
Division of the National Health Laboratory Service
Year
2025
Province
All
Facility Type
PUBLIC
Specimen Type
BLOOD CULTURE
Organism
ACINETOBACTER BAUMANNII
Antimicrobial
All
Age Category
All
Total Number of Cases per Month
Total Cases
4,282
Number of Cases
January
February
March
April
May
June
July
August
September
October
November
December
Year
2025
Total Number of Cases by Age and Gender
Gender
FEMALE
MALE
UNKNOWN
Number of Cases
Antimicrobial Susceptibility Testing Patterns by Year
% of Isolates tested
Antimicrobial Susceptibility Testing Results by Province
Province
S
S (%)
SDD
SDD (%)
I
I (%)
R
R (%)
Total Tested
Not Tested
EASTERN CAPE
1306
38%
2068
60%
3445
2627
FREE STATE
612
26%
1500
64%
2334
1858
GAUTENG
3284
33%
2
0%
392
3.9%
6316
63%
9994
9849
KWAZULU-NATAL
2442
45%
130
2.4%
2886
53%
5458
4140
LIMPOPO
633
43%
62
4.2%
780
53%
1475
1141
MPUMALANGA
727
36%
68
3.4%
1213
60%
2008
1736
NORTH WEST
451
33%
50
3.7%
851
63%
1352
1024
NORTHERN CAPE
47
18%
19
7.1%
202
75%
268
284
WESTERN CAPE
503
38%
43
3.2%
778
59%
1324
1148
Total
10005
36%
2
0%
1057
3.8%
16594
60%
27658
23807
Antimicrobial Susceptibility Testing Patterns by Drug
% of Isolates tested
AMIKACIN
CEFEPIME
CEFTAZID...
COLISTIN
GENTAMI...
IMIPENEM
MEROPE...
MINOCYC...
TETRACY...
TIGECYCL...
S - Susceptible
SDD - Susceptible Dose Dependent
I - Intermediate
R - Resistance
National MRDO Incidence Map
AMR Dashboard (National)
Private vs Public AMR Dashboard (National)
Dashboard Memo

c)

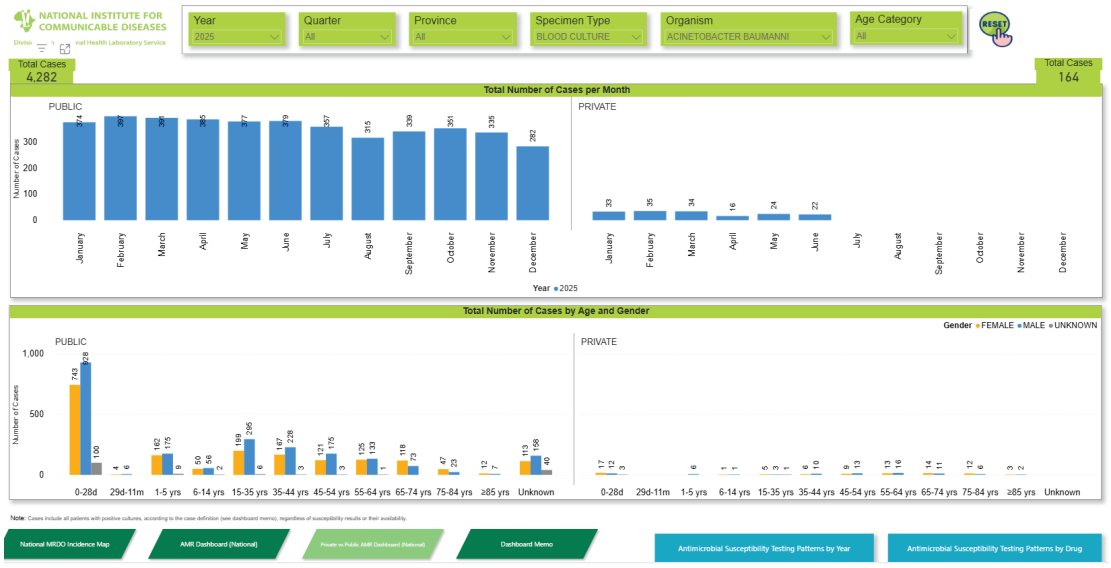


Figure 3. Antimicrobial resistance dashboard from the South African National Institute for Communicable Diseases (NICD, 2023-2025). The dashboard provides overall picture of AMR across South Africa incidence rate of resistance organisms per province (see Figure 3a for details), the susceptibility testing results per province and per medicine (see Figure 3b for details), and the monthly case load patterns (see Figure 3c for details). Data is shown for the 2025 calendar year (NICD, 2023-2025).

Six PHC facilities in the Johannesburg Metro region in South Africa were studied, and the results showed that interventions in this case, AMS education led to improved prescribing practices (Hlalo, 2018). Challenges were identified by Sharma (2023) by engaging with formal healthcare workers and CHWs. The study focused on the identification of challenges in the AMR landscape and the delivery of primary healthcare to the population in the Makana sub-District. After interviews and focus group discussions with medical doctors, nurses, dentists, pharmacy personnel and CHWs, the following themes and sub-themes were identified about the AMR landscape in Makana:

- Current AMR-related practices and protocols
- Most common and/or challenging infections
- Route of administration
- Patterns of irrational prescribing
- Key points when prescribing and dispensing antibiotics
- Encountering AMR
  - Practices and protocols when encountering AMR
  - Laboratory tests

- ○ Practices and protocols when AMR is detected
- ○ Hygiene-related practices and protocols
- • Waste management and infection control
- ○ Waste management
- ○ Infection control
- ○ Challenges with infection control
- • Contributing factors to AMR
- • AMR-related challenges
- • Influence of family, peers, neighborhood, environment, and culture
- • Patient motivation
- • Education on AMR
- • Recommendations for AMR health information leaflet
- • CHWs
- ○ Key roles of CHWs
- ○ Challenges faced by CHWs
- ○ Motivation to work as CHWs
- ○ AMR-related trainings and education for CHWs
- ○ Contributing factors to AMR
- ○ Influence of family, peers, neighbourhood, environment, and culture
- ○ Patient motivation by CHWs
- ○ Recommendations for AMR health information leaflet by CHWs

Engagement with formal healthcare workers and community healthcare workers in gaining understanding about the local threats and risks due to AMR is critical to tailor the information content of the health promotion materials, that are to be used in tackling the AMR under local conditions (Sharma et al., 2025). Data from Sharma (2023) indicate that tactical level of decision-making is still complicated by some challenges, which have been addressed or where implementation is still underway. Therefore, information from this subsection indicates that major efforts and strides have been achieved in AMR management in South Africa. These touch mainly strategic and operational level of decision-making in the AMR landscape of the country. Tactical challenges remain and so the *utilitarian qubit* of AMR is being pushed to 1 (pleasure and the limitations of infectious disease outbreaks due to resistant pathogen strains). However, challenges in the tactical level of AMR management and decision-making exist closest to the patient. The role and challenges in the primary healthcare sector in relation to AMR will be investigated in more detail in the next subsection of this narrative bioethical review for South Africa and also for a broader context.

Primary Healthcare (PHC) settings and data in AMR management

Health is a human right, strongly confirmed by the Alma-Ata Declaration. The Alma-Ata Declaration confirmed that PHC services are required in order to provide the first level of contact with health care to communities (WHO, 1978). In 2018, the Declaration of Astana acknowledged the Alma-Ata Declaration of 1978 and reaffirmed their commitment towards strengthening PHC which is the foundation of a sustainable healthcare system for achieving Universal Health Coverage and health-related SDGs (WHO & UNICEF, 2018). PHC services were adopted in 1994 in South Africa, and the programme to re-engineer PHC services around South Africa was initiated in 2010 by the National Department of Health (Bheekie & Bradley, 2016; Naledi et al., 2011). Despite the above-mentioned programmes in South Africa, poor health outcomes are still prevalent due to the quadruple burden of diseases and the increased focus on curative health care rather than preventative or promotional health care (Health Systems Trust & South African Department of Health, 2011; Biney et al., 2020). This remains a challenge even after the COVID19 pandemic and it is one of the main drivers to implement single-payer healthcare system, a government-run system of health insurance, which is however facing major opposition and roll-out challenges (Medical Brief, 2024). The increasing burden of HIV/AIDS and tuberculosis in South Africa, as well as the on-going outmigration of healthcare professionals has increased the need for improved health services, resulting in pronounced promotion of CHW programmes nationally (Clarke et al., 2008; Sharma et al., 2025). The migration of healthcare professionals to developed nations or private sector healthcare facilities is further weakening public sector healthcare systems and widening health disparities (Benatar, 2013; George et al., 2013; Van Rensburg, 2014). The most recent reasons for the emigration of the healthcare professional include better remuneration abroad, lack of physical security and job satisfaction in the South African public health system (Mthombeni and Vincent Lambert, 2025). Recent challenges in the public healthcare facilities include the lack of state funding for the salaries of medical doctors (Sobuwa, 2025). Even though these facts have been disputed by the South African Minister of Health in recent years (NDOH, 2017), anecdotal evidence from the field seems to indicate that specific groups of professionals are in short supply (Mileham, 2025). In addition, there are challenges in the provision of therapeutic care where antimicrobial regimens are administered to patients to treat infectious diseases, and which are not completed or the medicines are rationed and shared between community members who are and who are not patients (Sharma et al., 2025).

The settings and landscape of the primary healthcare provision will have direct impact on the AMR management and development in a particular jurisdiction. Complications and challenges in the primary healthcare settings will have direct influence on the tactical execution of any plan or plans, strategies which are deemed necessary to

implement so that AMR can be tackled successfully. It will be imperative to identify crucial healthcare personnel that is most likely to be in regular contact with patients, i.e. personnel that will have to the most up to date information about the landscape in which AMR is developing in the given jurisdiction. These staff will have to be considered a critical source of information about the recent history of the AMR landscape changes, about the efficiency or lack thereof for any interventions, health promotion campaigns or policies that are implemented in the sub-national level of public healthcare systems to tackle AMR. As a public health problem and a public health emergency, AMR is to be tackled from an epidemiological point of view. This requires the following the people, place and time perspective…AMR must be described in the context of local conditions, these conditions and manifestation of AMR…the landscape of AMR must have some or most features in common with the global knowledge on the causation, unfolding and public health impacts of AMR. The role of human actors in AMR must be captured, i.e. the healthcare worker knowledge, challenges and conduct in dealing and managing AMR must be captured, data on it collected, analysed and understood. In addition, roles of other stakeholders must be understood, and those stakeholders will include patients, drug producers and suppliers. Their voices must be heard in the management of AMR and in successfully implementing strategies to tackle AMR on a long-term basis. Finally, the wider society and its role in the AMR management, increase or suppression must also be understood. This can be linkage between the AMR policies, global guidelines and programmes, and the local context of the AMR management at the sub-national, at the tactical level of the public healthcare system.

The time factor means that the data on the AMR development and potential challenges in a given jurisdiction need to reflect temporal progression of the AMR impacts on public health. Practically, the time perspective can be captured in several ways. Firstly, data collection and monitoring of various indicators can be and is ongoing… these are national systems on the monitoring of AMR, antibiograms, the genetic sequences of causative agents of infectious diseases, ABC analysis of the antimicrobial medicine procurement over time, qualitative feedback from healthcare workers and stakeholders in the public health system on health promotion effectiveness, on the policy implementation, on the resource needs of the healthcare workers themselves. Such databases can be joint point of monitoring and data reporting and sharing platforms between sub-national and national levels of the public healthcare system, or they can be such platforms where a nation state, such as South Africa communicates and bidirectionally shares data on AMR with the WHO. This type of data collection leads to the evaluation of policy implementation, resources constraints and potential challenges that healthcare workers face in the routine AMR management and tackling. This has largely been achieved in South Africa at the national and strategic levels, as well as on the operational fronts. However, the gaps still exist in tactical decision-making.

Secondly, the time perspective on the AMR-related data can be data collected from the healthcare workers where the healthcare worker conveys a message about unseen aspects of the AMR development in the public healthcare system in a given jurisdiction. These data are based on the lived experiences, memories and practical localised knowledge that healthcare workers, who have the most contact with patients that suffer from infectious diseases and who have the most first-hand knowledge about the local AMR landscape in the public healthcare system. Such data would, in an ideal case, also include the information being gathered from the patients and their barriers to competing antimicrobial therapeutic regimens when they are prescribed. If marginalisation, logistical or other constraints of the data collective about the second elements of the time perspective prevent interviewing of the patients, then the surrogates for their voice are the healthcare workers who are most in contact with patients in relation to AMR. Some of the data is being collected on and reported on in academic literature (Sharma, 2023), and some of these studies are used to devise localised AMR management solutions (Sharma et al., 2025). However, more structured and institutionalised way of conducting such studies is necessary.

The dimensions and application of the people-place-and-time perspective leads to the fact that quantitative and qualitative data will have to be collected, reports gathered and evaluated…with findings being shared among the national, regional and international healthcare stakeholders in order to manage AMR effectively. At the same time, different types of data will have to be evaluated and combined to manage the AMR as a public health threat, i.e. in order to understand and effectively tackle the threats and risks from AMR. Such data evaluation and dissemination will be based on the sequential, or mixed methods approach as outlined by Ivankova et al. (2006). Quantitative data will include diverse types of information, e.g. ABC analysis of antimicrobial agent procurement under local or national conditions, and their links to the AWaRe classification of antimicrobial therapeutic agents (Sharma et al., 2020). The National Antimicrobial Dashboard is also a good example of the quantitative data (NICD, 2023-2025). Additional information will have to be collected based on the healthcare workers, who are closest to the patients and patients themselves, through methods that capture the lived AMR experiences of the local stakeholders, e.g. oral history investigations (University of Cape Town, 2013), institutional history through the examination of local records and paper/digital resources (document analysis), and through ethnographic research (University of Virginia, 2025). Lack of all or some necessary resources for conducting AMS or similar AMR-management programmes, political barriers to implementation of AMR or access to data for the evaluation and analysis purposes, can lead to un certainty about the AMR management. This needs to be acknowledged in any AMR programme, data collection or evaluation system, and by all stakeholders involved in AMR management. These initiatives push the *utilitarian qubit* of AMR towards 1 (pleasure and lack of suffering

due to resistant pathogen and AMR-related infectious disease outbreaks). However, more needs to be done to increase success of AMR management at the tactical level of decision-making and AMR.

To achieve this, the healthcare workers must be equipped to deal with the AMR in their localised conditions and public healthcare settings, e.g. through the development and use of health promotion materials and other tools as suggested by many authors, e.g. Sharma et al. (2025). In South Africa, national frameworks to tackle AMR must filter down to the PHC level of care and tactical level of decision-making. For data collection and effective AMR management, it is necessary to identify the healthcare workers who are in the best position to assist to be the core staff in the data management in AMR management. These would be frontline healthcare workers who are closest to the patient. They understand best the challenges at the tactical level of decision-making. They can provide crucial information to push the *utilitarian qubit* to the value of 1 (pleasure and healing), or they can identify what drives the *utilitarian qubit* toward 0 (pain and the AMR-related suffering). This is done in the next subsection of the narrative bioethical review.

Health Workforce and Community Health Workers

There is a severe shortage of health personnel seen in Sub-Saharan Africa. The WHO *Global Strategy on Human Resources for Health: Workforce 2030* report anticipated that by 2030, there will be a global shortfall of 18 million health workers, with Africa and South Asia experiencing the greatest shortages (WHO, 2016a). According to WHO estimates, 44.5 basic health workers are required per 10,000 population to achieve the SDGs but barely half of WHO Member States currently reached the number of basic health workers required per 10,000 population to achieve the SDGs (WHO, 2016a). One crucial answer to this issue is to increase the number and scope of CHWs (Sharma et al., 2025). In sub-Saharan Africa, there have been at least 3.7 million volunteer CHWs and 637,000 paid CHWs working in national CHW programmes that are not, in many cases, a part disease-specific programmes in recent years (Hodgins et al., 2021; Masis et al., 2021). When trained and supported appropriately, CHWs can significantly reduce workforce shortfall and impacts of processes such as healthcare work emigration in the public healthcare systems. CHWs are a crucial building block in strengthening PHC systems and for achieving Universal Health Coverage which will help to further advance the achievement of health-related SDGs (Perry et al., 2016). CHWs can effectively serve populations that are difficult to reach with healthcare services thus expanding access to key healthcare services and promote healthy behaviours. In addition to the provision of community-based service, this will allow for broader societal goals such as leadership and empowerment (Masis et al., 2021).

The roles and tasks of CHWs are tailored to address the requirements of the communities they work with, including but not limited to the following (Rural Health Information Hub, 2023):

- Bridging the gap between disadvantaged communities and healthcare professionals
- Managing care and the transition of care for vulnerable groups
- Informing stakeholders and healthcare professionals about community health requirements
- Ensuring that the healthcare professionals serving vulnerable groups are culturally competent
- Give culturally appropriate health information on subjects including the prevention of chronic diseases, physical activity, and nutrition
- Encouraging the provision of services and resources to underprivileged groups or communities to address their healthcare needs
- Providing informal counselling, health screenings, and referrals
- Increasing community capacity to address health-related problems
- Addressing the social determinants of health

Approximately 84 % of the South African population relies on public sector healthcare facilities for access to healthcare (Maphumulo & Bhengu, 2019). As there is a shortage of healthcare professionals, the prevention of illness and promotion of health are considered subordinate to finding the cure for illnesses, which is prioritised (Department of Health Republic of South Africa, 2012; WHO, 2017b). However, recent health promotion programme and materials development can contribute to prevention of AMR (Sharma et al., 2025). This is especially significant, given recent reports that patients often do not fully adhere to the prescriptions when antimicrobials are dispensed to them (Sharma et al., 2025). This does have practical impacts on AMR management in South Africa and for the majority of the country's population. Seeing that CHWs in South Africa were not deployed effectively to counteract shortages in health human resources, and that their primary focus was health promotion, the South African Departments of Health and of Social Development formed a partnership in order to review the CHW policy framework of 2004, and a new term, 'Community Care Workers' (CCWs), was agreed upon. The new name 'Community Care Workers' was more appropriate than "Community Health Workers", as it considers their role in health and social development (Health Systems Trust & South African Department of Health, 2011). However, CHWs is still in use in some parts of South Africa (Sharma et al., 2025).

It is crucial that CHWs are trained in curative, preventive, and promotive health care, as such training would assist in tasks being performed attentively and reduction in antimicrobial misuse, which is vital, since CHWs are the first level of contact with health care available to communities (Brink et al., 2016; WHO, 1978). Some training programmes in

South Africa are provided by the National Department of Health, which vary between one to two years. Other trainings are offered by non-governmental organisations (NGOs) and community-based organisations. It is important to note that not all CHWs have had a chance to receive training and be certified, especially in rural areas (Health Systems Trust & South African Department of Health, 2007). CHWs can play a vital role in health communication by promoting social support and engaging better with the community (Health Systems Trust, 2011). Ongoing engagement with the healthcare workers about the current status of the AMR threats and risks is critical to the effective management and prevention of infectious disease outbreaks due to resistant microbial strains. This would especially apply to the tactical level of AMR management, which has been shown to be problematic in South Africa (see previous subsection of the narrative bioethical review). CHWs are of critical importance in this regard, as they are at the boundary between the public healthcare system, and the patients. For example, the CHWs are the part of the stakeholders who follow up on the patient in their homes and to maintain regimen adherence for antimicrobials. As a result, the CHWs can be a critical data source for quantitative data, e.g. rates of adherence to regimens, and the qualitative/oral history/ethnographic data on the localised landscape of AMR in a jurisdiction. Therefore, engaging CHWs in AMR management in a more integrated and holistic way can also provide more information about the unseen qualitative information about the AMR landscape in local jurisdictions in South Africa. This can be achieved as reported by Sharma et al. (2025), and by oral history investigations. Combining these with qualitative data from local AMR monitoring and the Antimicrobial Resistance Dashboard, which is operated in South Africa (NICD, 2023-2025), can provide a holistic characterisation of AMR from the people, place and time perspective.

Lay workers, including CHWs as well as peer educators (Sharma et al., 2025), aid in the delivery of many health interventions and development of the health promotion materials to tackle AMR. Although lay workers may be recruited for a supportive role, within a health context, their aim is usually to bring about some form of health behaviour change or change in health outcome. While they have no formal professional training related to their role, they utilise their connections with the target group or community to reach individuals who would not normally readily engage with health services (Hodgins et al., 2016). A peer educational tool was used to promote AMS on an American university campus which proved to be successful, resulting in a 96.6 % post-assessment score as compared to the 69.5 % pre-assessment score (Lee & Bradley, 2021). Another study carried out in England indicated that peer education is an effective way to educate young people on antibiotics and hygiene (Young et al., 2017). Even though CHWs often do not have any or only have limited healthcare training, they are often closest to the communities at risk from AMR. They can effectively capture and relay to the formal public healthcare system stakeholders knowledge, often in near real time,

about the localised and current status of the AMR landscape. This can be harnessed at the tactical and operational levels of AMR management, and best case studies can be developed to tackle AMR under specific conditions, e.g. in low-resource settings. CHWs thus from a critical frontline resource in AMR management, and their increased involvement can help improve the delivery and prevention under local conditions of AMR landscape. In addition, CHWs can help identify obstacles and uncertainties to implementation of strategic and operation planning tools and legislation on AMR. CHWs can also provide valuable inputs that help ascertain the real threat of AMR in a given jurisdiction. In summary, CHWs can help address staff shortage in public healthcare systems and in the management of AMR. They can help push the *utilitarian qubit* towards the value of 1 (pleasure and prevention of AMR related suffering).

What is needed next is to unpack the approaches that have been used in AMR management, its tackling and potential novel tools to address the public health risks from AMR by CHWs and similar community health workers. Specifically, focus should be placed on strengthening tactical decision-making and supporting the frontline healthcare workers such as CHWs in playing a more active role in AMR management. CHWs can provide valuable perspectives on the cultural, sociological and other non-medical dimensions of AMR development in a specific community. This can be derived from the fact that all well-trained CHWs are frontline actor sin in the public healthcare sector. However, they are also laypersons who they can represent the voice of the patient in AMR development and management. This boundary position places a CHW as a perfect human reporter on the balance between pain and pleasure caused by AMR. Thus, CHWs can be a good source of pushing the *utilitarian qubit* towards the value of 1 (pleasure and elimination of suffering due to AMR). How to equip the CHWs to actively play a role in AMR management, along with the respective strategies, is outlined in the following subsections of the current narrative bioethical review.

Equipping the frontline healthcare workers with up-to-date information

Major gaps in knowledge and awareness of AMR and the lack of high-quality education and training tools to address AMR have been reported in literature over the years (Abbo et al., 2013; Dyar et al., 2013, 2014; Minen et al., 2010). Several factors can lead to the inappropriate use of antibiotics in healthcare facilities, such as a lack of knowledge or new information on antibiotic prescription, a lack of treatment guidelines, a lack of laboratory capacity to identify the organism and its antimicrobial susceptibility, unreliable or absent surveillance data on AMR and antibiotic consumption, unregulated over-the-counter use, and poor AMS. Training of healthcare staff must address these points and aspects of AMR management. Additionally, patient pressure to prescribe antibiotics and public expectations, and settings that allow for financial gain from the delivery of medicines may also lead to improper antibiotic prescription. Poor hygiene and sanitation in communities and inadequate adherence to infection prevention

and control measures in healthcare settings both contribute to the development of infections and thus increase antibiotic use (WHO, 2015b, 2018c, 2019a). CHWs can report the extent and significance of these factors in local AMR jurisdiction and landscape, and they can contribute to the management of these after proper training. The first goal of the WHO *Global Action Plan on AMR* aims to raise awareness as well as educate and train healthcare professionals and providers in order to improve their prescribing and dispensing practices (WHO, 2018c, 2019a). Effective communication, and the provision of education and training are key factors in raising awareness and understanding of AMR and promoting behaviour change (WHO, 2023e). Patients and communities in general require counselling and education on the correct use of antimicrobials and on never sharing or using leftover antimicrobials. Maintaining hygiene and sanitation by regularly washing hands and staying in clean environments are also important actions which require attention (WHO, 2018e).

Using a 'One Health' strategy, a project was carried out in Uganda to enhance AMS. With participation of 86 healthcare professionals, 227 CHWs and up to 300 students from local primary schools, training workshops took place with health education on AMR, AMS, and infection prevention and control. Three months after the training workshops, the project evaluation showed that 92.2% of healthcare professionals and 90.3% CHWs reported improved practices, including improved hand washing (57.3 % and 81.0 %, respectively). Moreover, 51.5 % of the healthcare professionals claimed a reduction in the irrational prescribing and dispensing of antibiotics. Therefore, this research illustrated that AMS interventions can enhance practices and promote the rational use of antibiotics in healthcare settings and communities (Musoke et al., 2020). A Cochrane study of AMS interventions also found that educational interventions significantly improved hospital prescribing practices and particular competences (Davey et al., 2017). This forms a possible template for assisting frontline healthcare workers such as CHWs in playing a well-informed and constructive role in AMR management. For effective and recognised operationalisation of such training programmes for CHWs, they should be anchored in the healthcare legislation in the given country. An example of how to practically execute this is outlined below for South Africa.

Under the South African National Health Act no. 61 of 2003, it is possible for the National Minister of Health to issue regulations which govern the deployment and training of human resources in the healthcare sector of the country (NHA, 2003-present). CHWs and formal healthcare workers on the frontlines of the AMR management should be supported by the provision of resources such as financial resources and additional resources to get training about AMR, to work with the community to manage AMR and to gain understanding about the emergence of new healthcare systems properties or behaviour that can be conducive to an increase in the AMR rates in given jurisdiction. To facilitate this in practice, regulations could be drafted to provide such resources, their sourcing and funding for the local district and sub-district offices of the Provincial

Departments of Health across South Africa. In particular, section 52a contains details about the possibility for the Minister to issue regulations which are necessary

> *"to ensure that adequate resources are available for the education and training of health care personnel to meet the human resources requirements of the national health system"* (NHA, 2003-present).

Training should be to recognised and accredited qualifications that allow for the frontline personnel to achieve recognition and improved professional standing in AMR management tin South Africa. The National Minister of Health in South Africa should include recognition of such qualifications in the AMR training regulation in line with the text of section 52b of the South Africa National Health Act no. 61 of 2003

> *"Ensure the education and training of health care personnel requirements of the national health system"* (NHA, 2003-present).

The AMR training should lead to accredited qualifications in South Africa. Looking at the registered qualifications with healthcare focus on South Africa, two possible qualifications could be modified as a way to increase the AMR knowledge base among formal healthcare workers and CHWs in South Africa. The qualifications in question include Occupational Certificate: Healthcare cleaner (SAQA, 2022-2025) and the Higher Certificate in Healthcare Management (SAQA, 2023-2026). The first qualification is based on the certification and showing competencies in the overall repeated performance of the cleaning tasks which include the cleaning of hospital and healthcare facility environments (SAQA, 2022-2025). The infection control is a critical part of this curriculum and could be easily expanded to include AMR coverage. The prerequisite for the qualifications is the completion of 2 years of secondary education (SAQA, 2022-2025). This would provide the opportunity for most of the CHWs to register for such qualifications. Renaming of the qualification would be advisable to indicate the broader scope of the competencies gained and the training in general. In addition, the qualification is registered but no provider has been assigned to deliver at the time of the writing of this article and as of 2024 (Services SETA, 2024).

The second qualification is a proprietary one, as it is only offered by a private higher education institution in South Africa (SAQA, 2023-2026). The higher certificate has a recognition of prior learning policy component to it and so it can accommodate both formal healthcare workers and the CHWs (SAQA, 2023-2026). This second qualification is focused on healthcare systems management, front of house contact with the patient and healthcare ethics (SAQA, 2023-2026). Therefore, it would make a good basis for the training of healthcare workers who need to counsel patients on AMR. This is based on the need for the contact with the patient, and the management of the potentially scarce healthcare resources (antimicrobial agents must be used rationally to prevent their obsolete character in the healthcare provision to future generations; based on the higher certificate information; SAQA, 2023-2026).

One challenge could be the cost of the higher certificate which is 23000 ZAR per person per course in 2025 (Mancosa, 2025). The higher certificate is also intellectual property of the private higher education institution that registered it. A mechanism to pay for the education of formal healthcare workers and CHWs could include targeted funding provided in the annual South African budgets for the National and Provincial Departments of Health for their healthcare staff. The occupational certificate and the higher certificate should include the AMR-focused curriculum which has been proposed by the international organisations.

Up to 116 countries organised campaigns on antibiotic-related problems in 2018, and more than 100 countries participated in the World Antimicrobial Awareness Week (WAAW) in 2019 with almost 700 events recorded globally (WHO, 2023e), highlighting the recent actions taken towards raising awareness on AMR. *The Global Strategy on Human Resources for Health: Workforce 2030* (WHO, 2016a) complements the WHO *Global Action Plan on AMR* (WHO, 2015b) by providing alternatives for policy advice on more comprehensive policies and methods to improve education and training for healthcare professionals and providers (WHO, 2018c). However, this document does have a category directly applicable to CHWs. WHO then published the Health Workers' Education and Training on AMR Curricula Guide to assist users in customizing their own curricula to suit their circumstances and requirements. The modules relate to the areas of the WHO AMR competence framework, including the fundamentals that increase knowledge and awareness on AMR. There are set curricula for all healthcare workers, including CHWs and auxiliary workers (WHO, 2019a). This should be amended by the in-service training of the formal healthcare workers and CHWs, as well as the operationalisation of the semi-permanent contact and points/testing facilities (Nhokodi et al., 2023a,b). Such standardised curricula could be used in the above-mentioned AMR training programmes. Supporting the training of the CHWs and frontline healthcare workers will equip an important part of public healthcare system with the necessary agency to better assist in AMR management. This would in turn strengthen the tactical part of the decision-making in AMR management in given local jurisdictions. This would contribute to shifting the *utilitarian qubit of AMR* towards the value of 1 (pleasure and limiting the suffering of the patients due to AMR). What is necessary next is to facilitate a way that agency of CHWs and other stakeholders in the public healthcare system could be exercised. Possible strategies are suggested in the next subsection of this bioethical review.

Communicative Ecology for Health Communication

The Alma-Ata Declaration of 1978 and the Ottawa Charter of 1986 overtly recognise the critical role of community participation and the social determinants of health, and therefore describe the foundational principles for health communication (WHO, 1978, 1986). Health communication primarily focuses on

the determinants of health on an individual level, such as an individual's beliefs and attitudes. Health communication, which is able to inform, influence and encourage individuals to implement health related changes, is an enabler of risk reduction (Bandura, 2004; UNICEF, 2005). However, many health communication campaigns fall short of their objectives (Neuhauser & Kreps, 2014; Snyder et al., 2004), primarily because they place an excessive amount of emphasis on individual-level constructs, and disregard the social, cultural, interpersonal, and community contexts in which populations reside (Moran et al., 2016). It is therefore important for academic researchers to understand the communicative ecologies of the target group to develop effective health communication interventions (Broad et al., 2013). Strengthening communication across public healthcare systems is in line with the national and strategic frameworks to manage AMR, e.g. as mentioned earlier for South Africa (NDOH, 2015; NDOH/DAFF, 2017-2024).

Communicative ecology is the daily, complex network of information and communication in a person's life. It rests on the assumption that individuals will be more likely to change their beliefs and attitudes if participatory 'messaging' is designed and circulated using appropriate ecologies by people who are connected in a social network (Australian Research Council et al., 2007). Ecological approaches to understanding and changing health behaviour are becoming progressively more common, as these produce a more comprehensive understanding of the multiple factors that affect health outcomes. Consideration of the multiple levels of influence, inclusive of family, peers, the neighbourhood, as well as the broader culture or society, allows for the development of more comprehensive and sustainable interventions (Moran et al., 2016; Glanz et al., 2008). Communicative ecology is therefore a framework for understanding and advancing health communication (Moran et al., 2016). In addition, the interconnection of different contexts has the potential to enhance the effectiveness of interventions by not only focusing on increasing knowledge (an individual-level construct) but by also fostering interpersonal discussions (a micro-level construct) about health problems, which is more likely to promote behaviour change (Pietromonaco & Collins, 2017). Whenever feasible, it is important to directly examine the multileveled factors that influence an individual's health, where a combination of quantitative and qualitative methodologies may be most helpful (Moran et al., 2016).

Along with communicative ecology, a community-based participatory research approach can be used to ensure community participation in the implementation of health communication programmes (Garney et al., 2015). There are different ways in which communication and information flows amongst places and individuals, as some individuals rely on media such as television and radio, whereas others may not have access to these communication channels, and thus depend on face-to-face communication (Australian Research Council et al., 2007). Mass media, such as television and radio, have been used in some areas. However, while these techniques can enhance and reinforce interpersonal communication, none of them can replace

the interactive learning possibilities which come with face-to-face communication. Carefully designed print materials can be used to support the interaction between health workers and the community (Program for Appropriate Technology in Health, 1996). In addition, networking and exchange information about AMR progression allows one to share quantitative and qualitative data about AMR, which is critical for tactical decision-making under local conditions in a given jurisdiction. Communicative ecology allows for diversity of voices to be heard, providing a more complete picture about the status of the *utilitarian qubit* of AMR. It also provides a way to collect data to potentially evaluate whether pain or pleasure, or what balance of them exists in a given jurisdiction or AMR landscape.

The communication ecology approach proposes that one must cast a wider net to understand how people obtain misinformation (Walter et al., 2018). Social networks are the most effective way to understand and conceptualize communication ecologies, and have shown to significantly improve health outcomes (Vassilev et al., 2014, 2016). Using a social network approach disassociates an individual's actions and behaviours from being the only factor responsible for self-management, enabling analysis within a broader communication ecology (Morris et al., 2016; Walter et al., 2018). Social network analysis has the potential to explore interactions between health workers and enhance healthcare delivery networks, however, there is lack of evidence from LMICs with regards to the use of social networks in healthcare settings (Hu et al., 2021). Although the effects of a social network on an individual's attitudes and health behaviours are widely documented (Wyke et al., 2013), social networks are not recognised adequately in AMS programmes. Given what is already known about the importance of family and other social networks in health-related issues, it is advisable to take social networks into account when addressing the overuse and misuse of antibiotics, and promoting behaviour change (Ellis et al., 2019). In order for the communicative ecology to be of any use, and in order for the success of training and overall AMR management programmes, it is necessary to assess and take into account the health literacy of the AMR stakeholders. This is an important aspect of correctly passing on, evaluating and acting on data about AMR in a particular public healthcare landscape. Correct understanding, sharing and other information operations will be important in the comprehension of *utilitarian qubit* of AMR. It can also lead to potential challenges and uncertainty in AMR management, and challenges in interaction with patients in healthcare systems. Given this overall importance of health literacy in AMR management, its details are outlined in the next subsection of this bioethical review.

Health Literacy and AMR

Disseminating scientific knowledge to non-scientific audiences has grown in importance and popularity (Moore & Millar, 2021). Health literacy is an important concept in this context, and the WHO defines health literacy as

> *"representing the personal knowledge and competencies that accumulate through daily activities, social interactions and across generations. Personal knowledge and competencies are mediated by the organizational structures and availability of resources that enable people to access, understand, appraise, and use information and services in ways that promote and maintain good health and well-being for themselves and those around them"* (WHO, 2025b).

This means that health literacy will be linked to understanding the essence of knowledge about AMR, and the way that this knowledge is shared as data and information among the stakeholders in a given healthcare system. Success of AMR management at the tactical level of decision-making will mostly be impacted by health literacy. However strategic and operational level of decision-making, and especially policies to tackle AMR and their implementation, will be linked closely to health literacy of patients, healthcare workers and the community at large in the given jurisdiction.

Challenges have been occurring in AMR management, as the average literacy level has been declining as the need for medical care is increasing, resulting in an indirectly proportional relationship between individuals who are not well versed in health care information and their use of healthcare facilities (Reeves et al., 2020). It is important to address health literacy levels, as it entails people's knowledge, motivation and competences to access, understand, appraise, and apply health information in order to take health-related decisions in everyday life (Pavao & Werneck, 2021; Sorensen et al., 2012). Limited health literacy is associated with less participation in health communication and disease detection activities, riskier health choices, more work accidents, reduced self-management of chronic diseases, poor adherence to medication, increased hospitalization and rehospitalization, increased morbidity and premature death (Shamra, 2023). In addition, it greatly depletes the healthcare system's human and financial resources (WHO, 2013). In the case of AMR, health literacy issues may contribute to non-adherence and patients demanding for antibiotics for self-limited viral infections, resulting in the irrational use of antibiotics (Osborne et al., 2016).

Health literacy is a major issue in many LMICs due to the low general literacy rates along with under-resourced and underperforming healthcare systems (Meherali et al., 2020). Countries such as South Africa, India, and Mexico do not have separate strategies or resources for health literacy as it appears to be a more recent concept in these nations (The Economist Intelligence Unit, 2021). Furthermore, the emergence of policy action to address the health literacy challenge has been slow (WHO, 2013). However, it is important to note that populations with low literacy are not confined to the developing world. According to a Gallup analysis of data from the USA Department of Education, 54 % of Americans between the age group of 16-74 years have a reading skill below the sixth grade (Gallup, 2020). A study conducted across Europe showed that one in every three to almost one in every two Europeans may not understand essential health

information material (Baccolini et al., 2021). Another European survey showed that 12.4 % of the respondents had inadequate general health literacy and 35.2 % had problematic general health literacy (Sorensen et al., 2015). In fact, up to 60 % of patients have low health literacy, and the recommended readability level for health information is less than or equivalent to Grade 8 (Oliffe et al., 2019). According to research, 80 % of the global population lives in cultures that learn through listening and watching rather than reading and writing (Crain, 2018; Reeves et al., 2020).

Promoting health literacy can improve the health of future generations and enable healthcare professionals and interact with people in a more patient-centric manner. Health literacy is not only a key determinant of health, but it may also assist in addressing the challenges of misinformation and disinformation. Healthcare systems, healthcare providers, and individuals must all work together to promote health literacy (The Economist Intelligence Unit, 2021). The use of plain, simple language and cultural appropriateness can bridge the gaps between health messages and health messengers, thus addressing the issue of low health literacy (Malik et al., 2017). This can be done by developing literacy and local-knowledge appropriate health promotion materials that have been developed based on tactical level inputs in a given jurisdiction and based on the principles of communicative ecology (Sharma, 2023; Sharma et al., 2025). In a recent study, the implementation of a health information leaflet improved participants' health literacy scores and subjective health status. The results further indicated that a direct intervention, such as a face-to-face approach, may enhance older participants' functional, communicative, and critical health literacy, as well as their satisfaction with the health guide and subjective health status. The development and implementation of health information leaflets may encourage greater voluntary reading and use of the information contained therein, which may raise awareness in self-health management (Doi-Kanno et al., 2021). All these principles and the role of health literacy in AMR management are crucial to successful planning and decision-making at all levels of public healthcare systems. They are also critical to deciphering of the values, and state of *utilitarian qubit* of AMR.

Health literacy and its relation to AMR management will be an important and ongoing issue at the boundary between the formal public healthcare sector of a given jurisdiction, and the patients or wider community. For CHWs, health literacy will be of specifically high importance, as they will be both patients and agents of AMR management. Knowledge about AMR, training and the ability to make patients, even with increased health literacy, will still potentially not be enough to tackle AMR, if the behaviour of stakeholders in the public healthcare system will be counteractive to fighting AMR. This is explored in the next subsection of the article below.

Behaviour Change, community engagement, action research and AMR management

Antibiotic mainstreaming is a strategy to encourage behavioural changes around antibiotics. Antibiotic use in humans is influenced by a variety of factors, such as knowledge, attitudes, social norms, socioeconomic conditions, peer pressure, personal experiences, and the socio-behavioural environment. Furthermore, key concepts are frequently interpreted differently by different people (Stålsby Lundborg & Tamhankar, 2014). The idea of gender mainstreaming has long been acknowledged (Ravindran & Kelkar-Khambete, 2008), and other concerns, such as HIV/AIDS have also tried to be 'mainstreamed' (Elsey et al., 2005). The main concept behind mainstreaming is to always make the mainstreamed problem an essential component of the planning; analyse each societal decision from the standpoint of the mainstreaming issue; and make the implications of the decision evident. Antibiotic mainstreaming has the potential to be an extremely effective, beneficial, and successful strategy for facilitating all forms of behaviour change that are required in communities to sustain the effectiveness of antibiotics, including increasing awareness and reducing the misuse and overuse of antibiotics (Stålsby Lundborg & Tamhankar, 2014). In relation to *utilitarian qubit* of AMR, antibiotic and antimicrobial mainstreaming can provide an additional approach to eliminate the uncertainty in the value or values of the 0 (pain) and/or 1 (pleasure) in patients. This is especially important in a country like South Africa with high burden of infectious disease in the public healthcare system.

In order to promote behaviour change, particularly amongst healthcare professionals and providers, it is important to understand the factors that can influence prescribing and dispensing decisions. Table 1 below shows the factors that may influence prescribing or dispensing decisions at the macro and micro levels (Stålsby Lundborg & Tamhankar, 2014). The European Union Joint Action on AMR and Healthcare-Associated Infections (EU-JAMRAI) developed an eight-step technical guide on how to develop a Social Behaviour Change Communication strategy to tackle AMR, and the eight steps are as follows (EU-JAMRAI, 2021):

1. Research and analyse the situation
2. Analyse your audience
3. Define the communication objectives
4. Build the message
5. Know the communication channels
6. Plan Social Behaviour Change Communication activities
7. Implement the plan
8. Evaluate and measure your impact

Factors Influencing Prescribing and Dispensing Decision at the Macro Level	*Factors Influencing Prescribing and Dispensing Decision at the Micro Level*
• Legislation • Drug policy • Pharmaceutical companies • Resources • Education • Available health care • Available information • Available antibiotics • Clinical practice guidelines • Disease and resistance patterns • Culture	• *Patient – gender, age, disease* • *Personal/professional knowledge and experiences* • *Available information* • *Perceived risks/benefits* • Emotions • Social influence • Healthcare professionals • Practice related factors • Self-efficacy • Continuing Professional Development

Table 1: Factors influencing prescribing or dispensing decisions at the macro and micro levels

It is clear from Table 1 that if the strategic and operational levels of decision-making, and concurrent tactical actions are taken to AMR, then antibiotic and antimicrobial mainstreaming can be achieved.

Participatory action research is an action- and reflection-based approach which involves finding answers to health-related research questions (Baum et al., 2006). Community based participatory research (CBPR) is a collaborative research approach that aims to promote sustainable health and well-being (Tapp et al., 2013). Partnerships and relationships result in resources being shared, as well as in partners encouraging one another to work towards achieving a goal (Centre for Social Justice and Community Action, Durham University & National Co-ordinating Centre for Public Engagement, 2012). This is in line with oral history, communicative ecology and additional tools mentioned in this article can improve the information and data availability and sharing on the ground. This can also be exploited to improve tactical level decision-making on AMR in local jurisdictions. Health promotion materials and localised interventions can also be accomplished in this way (Sharam et al., 2025).

Behaviour change regarding the usage of antibiotics requires engagement with individuals to understand their personal experiences. Recent analyses, however, reveal that raising awareness and education alone are not enough to achieve sustainable behaviour change (Denyer Willis & Chandler, 2019; Haenssgen et al., 2018; Pearson & Chandler, 2019). Instead, it is advised that efforts concentrate on 'sustained' or 'systematic and meaningful public engagement' as mentioned in various WHO papers (WHO, 2015a, 2019b) and national action plans on AMR. This mirrors the objectives and principles of community engagement methodologies, which aim to build a partnership and collaborate with a particular community to co-design relevant and sustainable solutions to local challenges (Mitchell et al., 2019, 2022). Because of their complexity, community

engagement projects tend to be multidisciplinary and address several levels of questions around their primary research question. Formative work is frequently done at the start of such initiatives to engage the community and stakeholders, build trust, determine their needs, and gather baseline data via surveys and interviews. The projects then collaborate with the community to build an intervention, such as an AMR dialogue, hygiene guidelines, and health information materials. Community engagement strategies must allow communities to understand the purpose for submitting information (for example, completing a survey) and understand how the information will be utilized (for example, to show how only some people complete their antibiotic course). Mixed-method techniques enable knowledge exchange between the researcher/s and community, ensuring that the project is context-specific and the engagements allow all stakeholders to learn and share their knowledge and experiences (Hassenforder et al., 2016; Mitchell et al., 2022). This stimulates communicative ecology, collaborative and data sharing, as well as trust among public healthcare stakeholders.

It is important to note that the cultural beliefs can influence health-related priorities and behaviours, which may further impact decisions and actions towards the acceptance and adoption of health communication programmes and messages (Kreuter & McClure, 2004). Culture is a system of shared values, beliefs, norms, practices, and ways of life within a given society (Abramson, 2012; Koenig et al., 2014). There are many cultural differences amongst people of different ethnicity, race, and language, and all cultures have systems of health beliefs. The more patients perceive educational interventions as having cultural relevance to them, the more they will accept and practice the actions and behavioural changes advised (EuroMed Info, 2023). Health researchers and policy makers therefore adopt a more culturally sensitive approach when designing, testing, and implementing health interventions targeted at communities (Merzel & D'Afflitti, 2003). Kreuter et al. (2003) described the five main strategies which are useful in bringing about culturally sensitive health communication, and the strategies are briefly described in Table 2 below (Kreuter et al., 2003).

Strategies	***Description***
Peripheral strategy	*Use of features such as layout, colours, and pictures in HILs which the target group can relate to*
Linguistic strategy	*Use of the home language of target group*
Evidential strategy	*Use of evidence and statistical data to make an impact on the behaviour of the target group*
Constituent involving strategy	*Use of the target group in planning and decision making to improve intervention acceptability*
Sociocultural strategy	*Use of cultural beliefs, values, and norms of the target group to achieve the intended health behaviour*

Table 2: Strategies for enhancing culture sensitive health communication

Qualitative research requires rigour in order for findings to be seen as credible and valuable (Long & Johnson, 2000). To enhance the rigour of qualitative research, four criteria inclusive of credibility, transferability, dependability, and confirmability are commonly used. The criteria are briefly described in Table 3 below (Shenton, 2004).

Criteria	***Description***
Credibility	*The degree of accuracy of the findings*
Transferability	*The degree to which the findings can be applied in other contexts*
Dependability	*The consistency of the findings and whether the study can be repeated*
Confirmability	*The adequacy of the information reported and the degree to which the findings can be confirmed by others; proving that the findings emerge from data and not from the researchers' own predispositions*

Table 3: Criteria for credible and valuable qualitative research

Adhering to the criteria in Tables 2 and 3, it is possible to collect qualitative data which is culturally-appropriate, where the tactical AMR landscape of the local environment and how this environment is experienced by the healthcare workers, can be captured. Voices of all AMR stakeholders can be heard, and AMR management becomes more inclusive. Communicative ecology and targeted training can be derived from such efforts, and the AMR management procedures can be optimised. Ultimately, this would contribute to the *utilitarian qubit* of AMR to be shifted more towards 1(pleasure and lack of human or patient suffering due to AMR).

Conclusions

This article has noted that AMR is consistently increasing, with a major negative impact on global public health, especially in LMICs, which lack the financial and human resources within their healthcare systems. Gaps in tactical level of decision-making have been identified. Solutions are proposed to address the gaps at the tactical level of decision-making and to deal with uncertainty antimicrobial resistance development in the future. These include of targeted training mechanisms, which are legislated at the national level of government, and which empower frontline healthcare workers. These training programmes should be supplemented by the use communicative ecology in data gathering, and information sharing. It is also important to drive behavioural rigor in prescribing, dispensing, and therapeutic uses of antimicrobial medicines in public healthcare systems. Finally, health literacy of all stakeholders should be continuously monitored in relation to antimicrobial resistance.

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