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# Antimicrobial resistance: The threat we can see, if we choose to look

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## Summary

Antimicrobial resistance (AMR) is a global public health threat that affects humans, animals, and the environment from a One Health perspective. It undermines our ability to treat common human and veterinary infections, threatens food security, and results in severe morbidity and mortality in many vulnerable patient populations. There are a number of important drivers of AMR in human, animal, and environmental sectors, such as overuse and misuse of antimicrobials. Vital mitigation strategies include appropriate stewardship of antimicrobials and infection control. However, none of these can be effectively implemented without well-designed, robust surveillance programmes at the foundation. A formal, funded national One Health AMR programme is urgently needed to ensure that South Africa is not only reacting to AMR, but also preventing its spread and developing early warning systems for emerging resistance.


## The burden of antimicrobial resistance

Antimicrobial resistance (AMR) remains one of the most critical global health threats, which could result in 169 million people dying of AMR-related causes between 2025 and 2050.[1] Despite the magnitude, it is a "silent pandemic" because it receives far less attention than traditional pandemics. However, if we examine the problem closely with the appropriate surveillance tools, we will see clearly that it is a raging pandemic, rather than a silent one.

AMR refers to the microorganisms (i.e., bacteria, viruses, fungi, and parasites) that survive exposure to antimicrobial agents. Antimicrobials include antibacterial, antifungal, antiviral, and antiparasitic agents with usage overarching multiple sectors, including in the human and veterinary clinical spheres for patient therapy/prophylaxis and in the agricultural sphere for animal growth promotion and crop protection.

These resistant organisms spread across humans and animals and through the environment. This is therefore, not just a human problem, but a multi-sectoral One Health problem.[2] One Health is an integrative approach to health that recognises the connection between humans, animals, and the environment and emphasises the need for a comprehensive strategy that involves all sectors to effectively tackle the global threat of AMR.

Generating data on AMR is critical to understanding the dynamics of resistance transmission and acquisition, and to mitigating this global threat. Thus, surveillance of AMR is a significant component of a global solution to reduce AMR, with a key role in supporting policies and stewardship programmes. Responsible antimicrobial use is essential not only in human health but also in agriculture, where producers must balance animal welfare and food security with the need to preserve antimicrobial effectiveness. Strengthening surveillance from a One Health perspective, transparent data sharing, and cross-sector co-ordination will allow us to act early and act together.[3–5] These complementary systems recognise that AMR extends across human, animal, and environmental health. However, for many lowand middle-income countries (LMICs), the cost and infrastructure requirements of establishing and maintaining such systems remain key challenges to achieving comprehensive surveillance coverage.

## The state of antimicrobial resistance in South Africa

South Africa has a unique situation of contrasting risk factors in the population. On the one hand, there is a large burden of infectious diseases such as HIV and TB. On the other hand, there is a growing problem of serious non-communicable diseases (cardiovascular diseases, cancer, and diabetes), resulting in prolonged hospital admissions and medical interventions.[6] Consequently, as a result of both risk groups, antimicrobial usage in public and private health sectors is high, accompanied by an increasing prevalence of AMR.

A national action plan was available and active from 2014-2024. Its implementation was supported by the Ministerial Advisory Committee on AMR (MAC-AMR). This strategy employed a One Health approach to AMR and achieved several key successes, including the establishment of a national framework, multisectoral co-ordination, enhanced surveillance, the implementation of antimicrobial stewardship programmes in several healthcare facilities, and improved awareness of AMR amongst healthcare workers.[7]

South Africa also has a high density of industrial farming of food-producing animals, including cattle, poultry, and pigs. Antibacterial agents with similar spectra of activity to human medicines are routinely used for therapeutic and prophylactic purposes and growth promotion on these farms, with consumption in animals difficult to measure due to lack of sales and usage data. While legislation governing antimicrobial use in animal feed and veterinary practice exists, recent reviews highlight that South Africa's regulatory and surveillance frameworks are evolving.[8,9] Widespread antifungal use (mostly azole-like agents) for crop protection drives environmental fungal AMR.[10] Ongoing collaboration between the human, animal, and environmental health sectors presents an important opportunity to strengthen these systems and ensure harmonised approaches to antimicrobial stewardship.

Laboratory-based AMR surveillance for the ESKAPE bacterial organisms (*Enterococcus faecium*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, and *Enterobacter* species) is a national surveillance programme conducted by the National Institute for Communicable Diseases (NICD), a division of the National Health Laboratory Service. ESKAPE pathogens were chosen for AMR surveillance, as they are listed as critical or high-priority pathogens on the World Health Organization's (WHO) Bacterial Priority Pathogens List.[11] *Candida* species were also included because these are listed on the WHO's Fungal Priority Pathogen List.[12] Furthermore, because surveillance focused primarily on bloodstream bacterial and fungal infections, pathogen-resistance combinations prevalent in other infectious syndromes were not captured. This AMR surveillance system was designed as a two-tier programme, with tier one focusing on the collection of laboratory isolates and periodic clinical information as part of the GERMS-SA surveillance in South Africa from 2011 to 2021.[8] Tier two is an electronic surveillance system from routine public and private laboratories, which is presented on the NICD AMR dashboard.[13]

The NICD AMR dashboard integrates human clinical data from both public and private sector pathology laboratories, a unique public health AMR surveillance output for the country, region, and continent. The collation of the private sector data was made possible by the close partnership between the NICD and the South African Society for Clinical Microbiology (SASCM), a daughter society of the Federation of Infectious Diseases Societies of Southern Africa (FIDSSA). The dashboard consolidates routinely collected microbiological data, focusing on key pathogens from patients with bloodstream infections. These data contribute to reporting to the National Department of Health (NDoH) and the WHO's Global Antimicrobial Resistance and Use Surveillance System (GLASS). It also forms the cornerstone for tracking national trends in resistance, guiding empirical treatment recommendations, and informing public health policy.[14–16]

National surveillance data indicate high levels of resistance amongst common bacterial pathogens, mirroring those listed by the WHO as being of critical priority.[9] Table 1 summarises the prevalence of ESKAPE organisms and important resistance phenotypes nationally in 2024 based on data from the NICD's AMR dashboard.[17]

**Table 1.** Prevalence of ESKAPE Pathogens and significant resistance phenotypes causing bloodstream infections in South Africa, 2024.

| Organism | Public sector | Private sector | Resistance phenotype | Public sector | Private sector |
|---|---|---|---|---|---|
| *Escherichia coli* | 4 315 | 4 534 | ESBL | 1 139 (26.4%) | 1 088 (24.0%) |
| | | | CR | 72 (1.7%) | 14 (0.3%) |
| *Klebsiella pneumoniae* | 7 361 | 5 064 | ESBL | 3 953 (53.7%) | 3 355 (66.3%) |
| | | | CR | 1 584 (21.5%) | 1 543 (30.5%) |
| *Acinetobacter baumannii* | 4 803 | 406 | CR | 2 876 (59.9%) | 223 (54.9%) |
| Pseudomonas *aeruginosa* | 1 936 | 1 329 | CR | 353 (18.2%) | 295 (22.2%) |
| *Staphylococcus aureus* | 6 801 | 3 265 | MRSA | 919 (13.5%) | 392 (12.0%) |
| *Enterococcus spp.* | 5 288 | 1 819 | VRE | 87 (1.6%) | 24 (1.3%) |

ESB=Extended Spectrum Beta-Lactamase; CR=Carbapenem-resistant; MRSA=Methicillin-resistant *Staphylococcus aureus*; VRE=Vancomycin resistant *Enterococcus*

The emergence of resistance amongst fungal pathogens in recent years has also highlighted antifungal resistance as a critical public health threat. National laboratory surveillance has documented rising rates of fluconazole resistance amongst non-*albicans Candida* species and the emergence of multidrug-resistant *Candidozyma auris*, now endemic in more than100 hospitals in the country.[12] In the 2009–2010 sentinel surveillance, 53% (282/531) of *C. parapsilosis* isolates were non-susceptible to both fluconazole and voriconazole.[13] Routine antifungal susceptibility testing for less-common yeasts, other than *Candida* spp., remains limited at most pathology laboratories. Reference testing is performed exclusively at the NICD's mycology reference laboratory, typically for clinically complex or refractory cases, thereby constraining the scope of national fungal AMR surveillance.

Despite recent advances, notable gaps in surveillance persist. Current electronic surveillance systems in South Africa are healthcare facility-based, resulting in the under-representation of AMR amongst communities not actively seeking healthcare. Furthermore, routine data from primary healthcare facilities are often sparse as a result of syndromic treatment algorithms. Due to resource limitations, longitudinal surveillance for ESKAPE bacterial and fungal pathogens has not been possible in South Africa. This has resulted in limited and fragmented pathogen-specific data, including genomic profiles and reference method-derived minimum inhibitory concentrations for key antimicrobials.

At present, animal and environmental surveillance for AMR in South Africa are predominantly research-driven.[18–20] Wastewater surveillance for carbapenem-resistant *Enterobacterales* (CRE) and fungal pathogens offers valuable early warning potential, but without linkages to animal and environmental data, its findings are difficult to translate into targeted interventions. International experience shows that wastewater monitoring is most effective when integrated with broader One Health surveillance systems that include data from agriculture, food production, and environmental sources.[21] In an effort to address these gaps, wastewater surveillance for CRE and fungi in clinical and environmental isolates is underway.[14]

Incomplete data for key pathogens across sectors limits the ability to target infection prevention, stewardship, and control measures effectively. Complementary data from animal and environmental surveillance, such as antimicrobial use patterns, resistance profiles in food and water sources, and links between environmental contamination and human exposure, are essential to guide co-ordinated AMR mitigation efforts across the One Health spectrum.

## Drivers of AMR and public health impact

The drivers of AMR are multifaceted and interconnected, encompassing biological, behavioural, social, and systemic factors.[15] In Africa and other LMICs, where the burden of infectious diseases remains high, these drivers are further amplified by weak health systems and limited resources.

A major contributor to AMR is the overuse and misuse of antibiotics and antifungals in humans and animals. In healthcare facilities, antibiotics are frequently prescribed empirically, in the absence of laboratory confirmation. Recent Global Point Prevalence Survey (GLOBAL-PPS) data recorded that almost 90% of patients were prescribed antibiotics empirically.[22] Similarly, the unregulated use of antifungals in agriculture and human medicine has accelerated the emergence of resistant fungal species such as *C. auris* and azole-resistant *Aspergillus fumigatus*.[23] In animal husbandry, the use of antibiotics for growth promotion and disease prevention further compounds selective pressure, promoting the spread of resistance genes through the food chain, the environment, and subsequently to humans.[24]

The lack of access to rapid diagnostics in human and animal health significantly contributes to inappropriate antimicrobial use in humans and animals. According to Gasson *et al.*, incorrect use of antimicrobials in primary healthcare is up to 55%.[25] This diagnostic gap delays appropriate treatment, promotes the unnecessary use of broad-spectrum agents, and prevents timely identification of resistant pathogens. Antifungal resistance is often under-recognised due to the scarcity of fungal culture facilities and molecular diagnostic tools, resulting in misdiagnosis and treatment failure.

Poor infection prevention and control (IPC) practices in human health, coupled with inadequate sanitation, hygiene, and water, sanitation, and hygiene infrastructure, further accelerate AMR transmission within healthcare and community settings. Overcrowded hospitals, insufficient isolation facilities, and shortages of basic supplies such as disinfectants and sterile equipment enable resistant organisms to spread easily. Inadequate sanitation and contaminated water sources extend this problem into the community, perpetuating cycles of infection and antibiotic use. [26,27]

There is still a lack of reliable antimicrobial consumption data in human and animal health, with data limited to procurement or import data in the public sector and data from the private sector that are not inclusive of all private groups.[14] In addition, the last consumption data report is from 2022, with PPS data available for 2023. This fuels inappropriate prescribing and reactive policymaking, rather than evidence-based, proactive interventions.

## Recommendations for best practice to address AMR in South Africa

Several important steps can be taken at various levels of society to address this critical public health issue in South Africa. Figure 1 provides a visual summary of recommendations, with only pertinent recommendations discussed in the text.

**For government**:

At the governmental level in South Africa, the first and most critical need is a dedicated, formal, funded multisectoral AMR programme with sustainable resources (such as human resources, consumables, systems support, etc.), clear governance, and measurable targets. The WHO's Global Action Plan on AMR, initially published in 2016, is being updated, with a strong focus on One Health responses as a result of gaps identified through review of the National Action Plans on AMR globally.[28,29] South Africa's efforts can contribute towards regional and global progress with a common goal by aligning activities and targets of the programme with the country's National Action Plan for Health Security (NAPHS).[30] The NAPHS is a country-led, multi-year plan to strengthen capacity to prevent, detect, respond to, and recover from public health emergencies, which adopts a multisectoral, One Health approach aligned with the International Health Regulations (IHR 2005). AMR is one of 19 technical areas included in the NAPHS. Naturally, a critical activity of the NAPHS AMR technical area is to secure an updated national action plan for AMR, which expired at the end of 2024.

Secondly, prioritisation and adequate resourcing (human and financial) of national AMR surveillance programmes are essential as the backbone of the national response to AMR. National public health institutions, such as the NICD, play a critical and central role in monitoring for resistance prevalence and the detection of novel and emerging resistance mechanisms. Previous successful initiatives have been supported through external grant funding. Sustaining progress will require stable and ongoing domestic investment to support core staffing and essential laboratory operations.

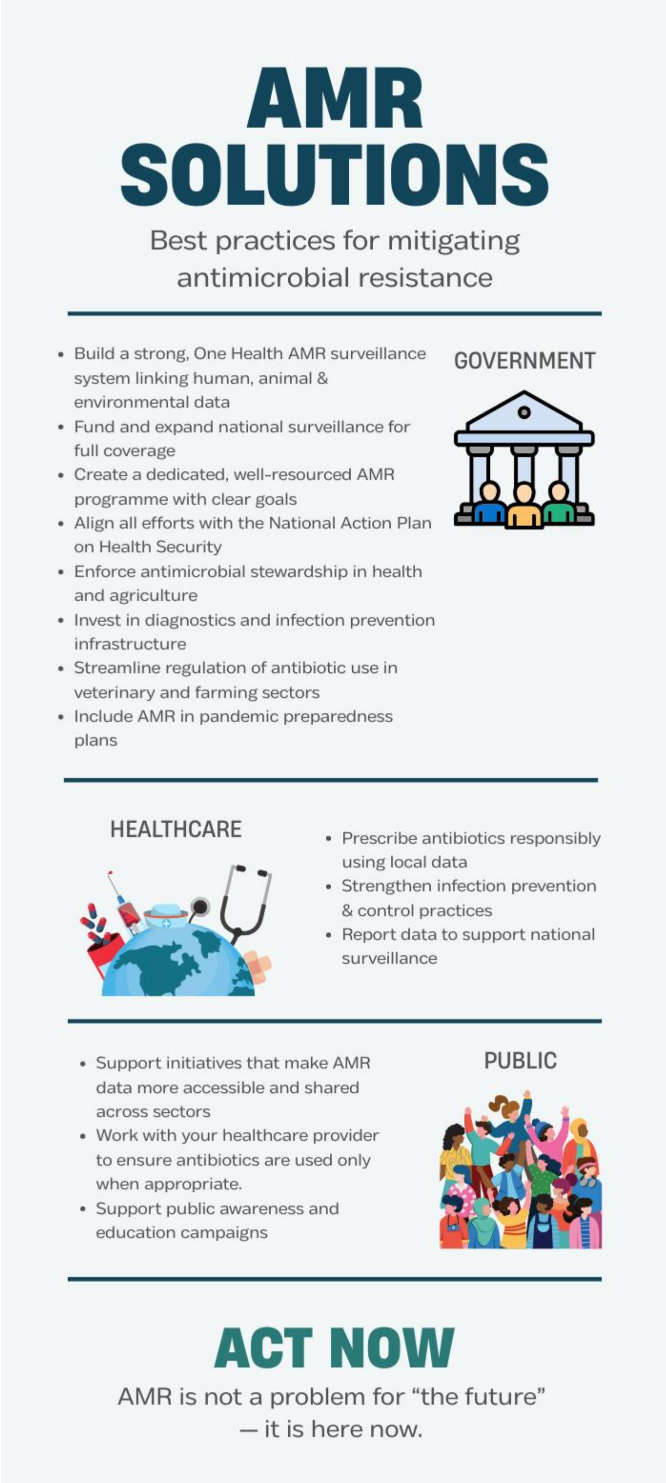


**Figure 1.** Best practices for mitigating antimicrobial resistance.

It is important that the AMR surveillance strategy is integrated under a One Health framework, as recommended by the WHO and the quadripartite joint secretariat on AMR.[22,23] Combating AMR requires recognising the close interlinkages between human, animal, and environmental health and fostering platforms for data sharing and joint action. Even if surveillance systems differ, agreement on core data elements – such as antimicrobial use and resistance trends – can guide co-ordinated containment strategies and safeguard both public health and the agricultural sector. Examples from Denmark, the Netherlands, and Thailand show that integrated, cross-sectoral approaches are achievable and effective.[31–33] Such a system requires formalised agreements through government-led multi-sectoral co-ordination linking human, animal, and environmental sectors to develop an integrated surveillance system. Figure 2 outlines the important components of a One Health integrated surveillance system for AMR.

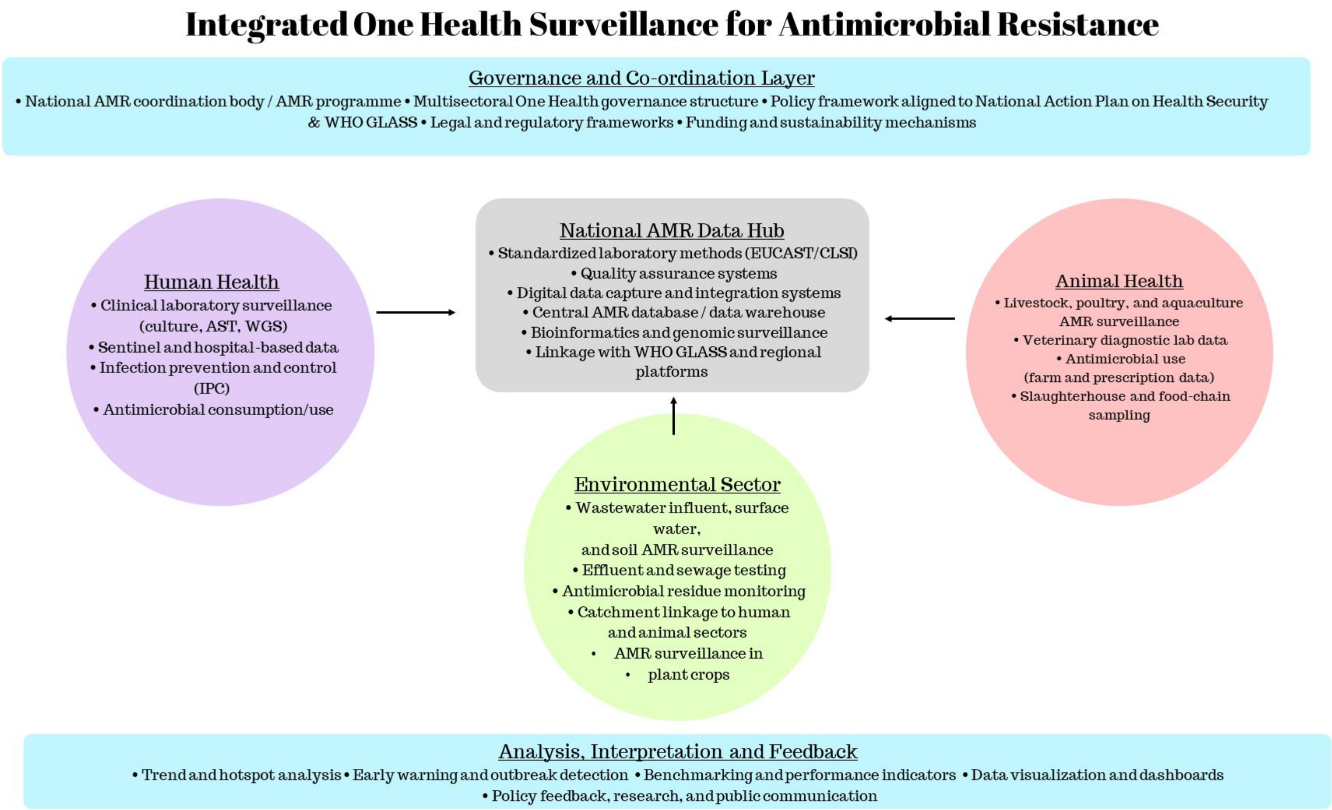


**Figure 2.** Integrated One Health surveillance for antimicrobial resistance.

GLASS = Global Antimicrobial Resistance and Use Surveillance System; AST = antimicrobial susceptibility testing, WGS = whole genome sequencing, EUCAST = European Committee on Antimicrobial Susceptibility Testing, CLSI = Clinical & Laboratory Standards Institute

Strengthening the alignment of regulatory approaches for antimicrobial use in animal health could help support more consistent practices across production systems. Clearer, co-ordinated guidance – developed together with veterinary, agricultural, and public health partners – would also enable more reliable monitoring of antimicrobial use. Over time, this can contribute to a more coherent national response to AMR across sectors.

Surveillance cannot be touted as a stand-alone solution to AMR. To meaningfully influence how antimicrobials are used in human, animal, and plant health, as well as in agriculture, stewardship must be embedded in policy and implemented across sectors. While stewardship strategies will differ in approach, context, and mechanisms across the different sectors, they share the common objective of promoting responsible antimicrobial use through monitoring systems that track consumption and assess the impact on resistance.

Furthermore, sufficient urgent strides need to be made to improve the availability of and access to laboratory diagnostics, particularly in the animal sector and for testing of environmental samples. Mitigation solutions and policy changes, in the absence of data on AMR in humans, animals, and the environment, are futile. Lastly, data without action are just noise. The importance of adequate IPC measures in healthcare facilities cannot be overstated, with many economic evaluations demonstrating that hand hygiene, environmental cleaning, and other multimodal IPC strategies are cost-effective compared to standard practice. If mandated by the NDoH, such important strategies can be prioritised at the institutional level.

**For healthcare workers in human health**:

Healthcare workers are encouraged to focus on appropriate antimicrobial use and effective use of surveillance data. Following the five "rights" of prescribing is the first step to take, i.e., ensuring the right drug is prescribed to the right patient, for the right diagnosis, at the right dose, and for the right duration, according to the AWaRe classification.[34,35]

**For civil society and the public**:

The involvement of civil society has been pivotal in policy change related to many diseases, including HIV/AIDS and COVID-19 vaccines and medication.[25] Civil society has many roles to play in mitigating AMR locally and globally by raising awareness and promoting responsible antimicrobial use across human, animal, and environmental health. This includes advocating for One Health reporting of surveillance data, supporting public education on appropriate antibiotic use, and participating in awareness initiatives such as World AMR Awareness Week. Sharing personal experiences of AMR can help highlight the impact of resistant infections, while continued advocacy for equitable access to critical antimicrobials remains essential. Although this paper has focused largely on human health, growing evidence shows that antimicrobial use in livestock, aquaculture, and the environment also contributes to resistance; strengthening cross-sector engagement will therefore be important as our understanding of these areas continues to evolve.

## Final words and a call to action

Although AMR data underscore an escalating global health threat over the next 25 years, it is not a problem of the future. It is very much a problem of the here-and-now, and it is accelerating year by year. There are a number of potential solutions that need to synchronise with each other and require input from various sectors. One cannot overstate the role of civil society in advocating for policy change to address AMR and to advocate for the responsible use of antimicrobials, responsible sharing of data, and changing behaviours around antimicrobial use.

South Africa stands at a crossroads. We can stand back and watch AMR overwhelm our hospitals, farms, and communities – or we can invest now in the systems that prevent it. Responsible antimicrobial use is essential not only in human health but also in agriculture, where producers must balance animal welfare and food security with the need to preserve antimicrobial effectiveness. Strengthening surveillance from a One Health perspective, transparent data sharing, and cross-sector co-ordination will allow us to act early and act together. Surveillance gives us the power to see this threat clearly; sustained, collective commitment will determine whether we use that foresight wisely or continue to look away.

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## Conflicts of interest

The authors declare no conflicts of interest.

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