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Brian Godman [a,b,c], Abiodun Egwuenu[d], Evelyn Wesangula[e], Natalie Schellack [f], Aubrey Chichonyi Kalungia [g], Celda Tiroyakgosi[h], Joyce Kgatlwane[i], Julius C. Mwita [j], Okwen Patrick[k,l], Loveline Lum Niba [k,m], Adefolarin A. Amu[n], Racheal Tomilola Oguntade[n], Mobolaji Eniola Alabi[o], Nondumiso B. Q. Ncube[p], Israel Abebrese Sefah [q], Joseph Acolatse[r], Robert Incoom[r], Anastasia Nkatha Guantai[s], Margaret Oluka[s], Sylvia Opanga[t], Ibrahim Chikowe[u], Felix Khuluza[u], Francis K. Chiumia[u], Collins Edward Jana[v], Francis Kalemeera [w], Ester Hango[w], Joseph Fadare [x,y], Olayinka O. Ogunleye [z,aa], Bernard E. Ebruke[bb], Johanna C. Meyer [c], Amos Massele[cc], Oliver Ombeva Malande[c,dd,ee], Dan Kibuule [ff], Otridah Kapona[gg], Trust Zaranyika [hh], Mutsa Bwakura-Dangarembizi[ii], Tapiwanashe Kujinga [jj], Zikria Saleem [kk], Amanj Kurdi [a,c,ll,mm], Moyad Shahwan [b,nn], Ammar Abdulrahman Jairoun [oo], Janney Wale[pp] and Adrian J Brink[qq,rr]

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ABSTRACT

Introduction: Antimicrobial resistance (AMR) is a concern as this increases morbidity, mortality, and costs, with sub-Saharan Africa having the highest rates globally. Concerns with rising AMR have resulted in international, Pan-African, and country activities including the development of national action plans (NAPs). However, there is variable implementation across Africa with key challenges persisting.

Areas covered: Consequently, there is an urgent need to document current NAP activities and challenges across sub-Saharan Africa to provide future guidance. This builds on a narrative review of the literature.

Expert Opinion: All surveyed sub-Saharan African countries have developed their NAPs; however, there is variable implementation. Countries including Botswana and Namibia are yet to officially launch their NAPs with Eswatini only recently launching its NAP. Cameroon is further ahead with its NAP than these countries; though there are concerns with implementation. South Africa appears to have made the greatest strides with implementing its NAP including regular monitoring of activities and instigation of antimicrobial stewardship programs. Key challenges remain across Africa. These include available personnel, expertise, capacity, and resources to undertake agreed NAP activities including active surveillance, lack of focal points to drive NAPs, and competing demands and priorities including among donors. These challenges are being addressed, with further co-ordinated efforts needed to reduce AMR.

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Article highlights

- Antimicrobial resistance (AMR) rates are growing especially in sub-Saharan Africa with increasing morbidity, mortality, and costs, with sub-Saharan Africa currently having the highest mortality due to AMR globally.
- Concerns with rising AMR rates have resulted in the WHO instigating national action plans to try and address AMR among countries. This includes African countries.
- While all surveyed African countries have developed NAPs, there is currently variable introduction and implementation across Africa, with key challenges persisting.
- Currently, South Africa appears to have made the greatest strides with implementing its NAP, which includes regular monitoring of agreed activities as well as instigation and monitoring of antimicrobial stewardship programs.
- However, sub-Saharan countries including Botswana and Namibia are yet to officially launch their NAPs with Eswatini only recently launching its NAP. Cameroon is further ahead with its NAP than these countries; however, there are currently concerns with implementation.
- Key challenges remain across Africa with implementing NAPs, although these are starting to be addressed. Key challenges include available personnel and expertise, lack of focal points to drive NAPs forward, and resources issues to undertake active surveillance of resistance patterns across sectors exacerbated by competing demands and priorities including among donors.

1. Background

1.1. General overview including antimicrobial resistance

The greatest burden of infectious diseases globally, including acute respiratory diseases, human immunodeficiency virus (HIV) and acquired immunodeficiency syndrome (AIDS), malaria, and tuberculosis (TB), is in sub-Saharan Africa [1–5]. Currently, HIV/AIDS, malaria, and TB account for over 1.2 million deaths per year across countries principally within sub-Saharan Africa [1]. Antimicrobial resistance (AMR) adds to this burden in a region with already inequitable access to essential medicines [6]. A recent study published in the Lancet estimated that 1.27 million deaths globally in 2019 were due to bacterial AMR, with the greatest burden in Western sub-Saharan Africa with Australasia having the least number of deaths due to AMR [6]. The COVID-19 pandemic has aggravated the burden of infectious diseases and antimicrobial use across sub-Saharan Africa; however to date, its perceived impact on morbidity and mortality appears to be less than for other endemic diseases including HIV/AIDS, malaria, and TB [2,7].

Challenges with health system infrastructure across sub-Saharan Africa, including regular access to clean water and good sanitation, exacerbated by poverty, coupled with the endemicity of HIV/AIDS, enhance the risk of infection and subsequent AMR [6,8–11], with COVID-19 further compromising healthcare infrastructures. The high rates of resistance to commonly prescribed and dispensed antibiotics across sub-Saharan Africa are further worsened by high rates of inappropriate prescribing and dispensing of antimicrobials, weak diagnostic capabilities, variable implementation of regulations concerning the dispensing of antimicrobials without a prescription as well as variable access to effective health care [5,6,8,12–21].

Other compounding factors that add to the challenges of rising AMR rates in sub-Saharan Africa include the availability of substandard or falsified antibiotics. This arises from currently weak regulatory systems, limited local manufacturing, and inadequate quality assurance testing of antimicrobials, as well as concerns with available professionals and co-operation between professional groups [1,22–26]. Concerns about the impact of substandard and falsified medicines in Africa resulted in the recent Lomé Initiative organized by the World Health Organization (WHO) [27,28]. This strategy included 12 actions, ranging from education to border control as well as from supply chain integrity to transparent legal processes. Two of the 12 suggested actions in the WHO's strategy relate to tightening of the legal frameworks to curtail this vice. The Lomé initiative has helped raise the priority for activities in this area as one of the key ways to reduce rising AMR rates [28], which will continue. This is important as there have been shortages of quality medicines across Africa in recent years including antimicrobials. Shortages also carry with them the potential to increase AMR unless proactively addressed through improved stock control, donor schemes, and agreed therapeutic interchange programs [29–32]. Concerns with shortages and their implications are likely to remain until there are sufficient structures in place to strengthen pharmaceutical supply chains across Africa [29,33,34].

Vaccines are also a key preventative measure to limit future infectious diseases and any subsequent inappropriate antimicrobial use with implications for the development of AMR [35–42]. Vaccines are also less likely to induce resistance [42]. However, there are concerns with current vaccination uptake and coverage against infectious diseases among African countries, which are affected by available facilities for their administration and poor communication, both of which can be addressed [43,44]. This is a critical issue with the role of vaccines generally undervalued across countries to counteract AMR [41]. Immunization rates across Africa have been further affected by lockdown and other measures to combat the spread of COVID-19 as well as fears of contracting the virus at primary healthcare facilities [35,45–50]. This is a concern given the implications for future morbidity and mortality among children, which are appreciably greater than the impact of COVID-19 among children across Africa [45,47,51]. In some countries, mobile clinics, as well as healthcare workers visiting families with unvaccinated children, have been instigated to address these issues [52,53], with such activities likely to grow. Alongside this, there is also a need to increase educational and other activities to address concerns with vaccine hesitancy, including for COVID-19, to reduce the subsequent occurrence of infectious diseases and AMR [35,54–57].

Additional activities to reduce AMR rates across Africa include ensuring that pertinent quality improvement programs are instigated across sectors to reduce inappropriate prescribing and dispensing of antimicrobials. These programs typically start in hospitals through ascertaining current antimicrobial utilization and resistance patterns, which includes conducting point prevalence surveys (PPS) [58–64]. The findings can subsequently be used to direct future quality improvement programs in hospitals across Africa. Such programs include the instigation of infection, prevention, and

control (IPC) committees and associated activities to reduce health care-infections (HAIs). This can be undertaken through antimicrobial stewardship programs (ASPs) where these currently do not exist [65–72]. Studies have also been undertaken regarding the management of surgical site infections (SSIs) across Africa, given concerns with extended antibiotic prophylaxis and the implications for adverse events and AMR [73–75]. The findings have resulted in a range of educational and other multimodal activities being instigated in hospitals to reduce high rates of extended prophylaxis postoperatively [76–78].

Additional activities that can be conducted as part of ASPs to reduce AMR include assessing prescribing against agreed criteria and antibiograms given variable rates of compliance to treatment guidelines among African countries [58,79–83]. However, there have been concerns with the level of knowledge regarding antibiotics and ASPs, as well as the extent of their implementation, among African countries due to resource limitations and other issues, especially in rural areas [84–92]. Encouragingly, this situation is now changing with ASPs increasingly being instigated across Africa [65,68]. These activities have been aided by a growing focus on AMR and antimicrobial use across Africa, coupled with the increasing availability of treatment and other guidelines across Africa [68,93,94]. This is seen as beneficial with ASPs known to improve future antimicrobial use as well as reduce costs and resistance rates across countries [65,67,95,96].

The WHO has also reclassified antibiotics into the Access, Watch, and Reserve (WHO AWaRe) list to help contain AMR [97,98]. The 'Access' group of antibiotics are considered as first- or second-line antibiotic choices for empiric treatment for up to 26 common or severe clinical syndromes. The recommended first-line choices of antibiotics in the 'Access' group typically have a narrow spectrum as well as low toxicity risk and resistant potential. The 'Watch' group of antibiotics are considered as having a higher resistance potential and side effects. Finally, the 'Reserve' group of antibiotics should only be considered as last resort antibiotics and prioritized as key targets for any national or local ASP [97–100]. Assessing antimicrobial prescribing against current guidance, and monitoring their use based on the WHO AwaRe list, is increasingly being undertaken across Africa to improve prescribing, which builds on examples globally [98,99,101,102]. This is because the AwaRe list provides robust quality indicators to improve future antimicrobial use across sectors [58,61,82,83,98,99,103,104]. Such activities are critical at this time with high rates of antimicrobial prescribing for patients with COVID-19 across countries, despite limited evidence of concomitant bacterial or fungal infections, adding to AMR concerns [105–113].

Another key concern is the current high levels of inappropriate prescribing and dispensing of antimicrobials in ambulatory care among a number of sub-Saharan African countries, especially for self-limiting conditions, including acute respiratory tract infections (ARIs) [14,15,35,114–116]. Furthermore, adherence to prescribing guidelines for patients with respiratory tract infections (RTIs) is currently needed to reduce inappropriate antimicrobial prescribing for these patients [80,117]. Successful programs have been introduced among physicians across countries, including other low- and middle-income countries (LMICs), to improve antibiotic prescribing, providing guidance to others [14,35]. Multifaceted interventions have generally been more successful than single educational activities to reduce inappropriate antibiotic prescribing [14,35,118,119]. Studies conducted in Kenya and Namibia have also shown that the presence of trained pharmacists in community pharmacies, alongside knowledge of the current regulations, can reduce inappropriate dispensing of antibiotics without a prescription especially for patients with ARIs [120–123]; however, this is not always the case for other prevalent infections seen in community pharmacies [124].

There are also concerns with increasing resistance rates in animals through the overuse of antibiotics, which exacerbate AMR in the human population [125–128]. This should also be a key element of multisectoral co-ordinated activities among African countries to reduce AMR given current concerns [93,129–132].

1.2. WHO Global Action Plan (GAP) and National Action Plan (NAP) among sub-Saharan African countries

High rates of AMR are a major challenge across countries as they increase morbidity, mortality, and costs [35,133–139], with AMR rates currently exacerbated by the overuse of antimicrobials to treat patients with COVID-19 [108,110,140,141]. For instance, the World Bank (2017) expected that even in a low-AMR scenario, the economic costs of AMR would be considerable. They estimated that the loss of world output arising from AMR could exceed US$1 trillion annually after 2030, and potentially up to US$3.4 trillion annually, unless AMR is addressed. This would be equivalent to 3.8% of annual Gross Domestic Product [142]. In any event, the costs of AMR will appreciably exceed the costs of any antibiotics prescribed or dispensed across sectors [143].

Concerns with rising AMR rates across countries, including sub-Saharan African countries, and the implications on costs and health, have resulted in many national, regional, and international initiatives to try and reverse this trend. The WHO/Food and Agriculture Organization of the United Nations/World Organization for Animal Health (WHO/FAO/OIE) action plan in 2015 resulted in several global activities. These included the Fleming Fund to tackle AMR, the Interagency Coordination Group on Antimicrobial Resistance (ICGAR) group, the Organization for Economic Co-operation and Development (OECD), and the World Bank initiatives. These activities ran in conjunction with global educational and other initiatives, along with co-ordinated activities at regional and national levels [14,144–157]. We have also seen the development of the first African guidelines for treating common bacterial infections across age groups, with such activities likely to grow given ongoing concerns with rising AMR rates across Africa [158–160].

The GAP of the WHO has resulted in the development of NAPs across countries to reduce AMR [147,148,161–166]. However, there are concerns with their implementation, including among African countries [93,167]. Poor implementation has resulted in renewed calls from the WHO to tackle AMR [168], as well as developing handbooks to help with the

implementation of NAPs [169]. In addition, regular monitoring is needed regarding their implementation to optimize their impact [170].

Against this background, we sought to ascertain current issues and challenges associated with the implementation of NAPs across sub-Saharan Africa to reduce AMR rates. Box 1 lists identified pillars within the Global NAP in order to provide direction to individual countries [93,161]. The findings can be used to help guide future activities.

Box1. Five Strategic Pillars within the WHO Global Action Plans to reduce AMR (adapted from [72,93,161,164])

(1) Improve awareness and understanding of AMR among all key stakeholder groups
(2) Strengthen knowledge of AMR through improved surveillance and future research activities
(3) Seek to reduce the incidence of infections
(4) Introduce pertinent programs to optimize the future use of antimicrobials
(5) Develop an economic case for sustainable investment for new medicines, including new antibiotics, new vaccines, diagnostic tools, and other pertinent interventions to help counter growing AMR rates. In addition, promote research on AMR

In their recent study, Elton et al. documented concerns with the overall preparedness of sub-Saharan African countries to tackle AMR [93]. However, there was considerable variation among the countries with East Africa being the most prepared. Southern Africa scored highest for the routine reporting of resistant pathogens and highest for IPC training [93]. Overall, only 25% of sub-Saharan African countries had NAPs in place and only 32% had been conducting routine AMR surveillance, with a similar number stating that they had national guidelines in place for the distribution and use of antimicrobials [93].

As of 31 December 2019, 33 African countries had produced their NAPs, with 16 endorsed at the Government level [8]. This was built on the study by Iwu and Patrick (2021) which documented the implementation of NAPs among the WHO African region in 2018/2019 [72]. There were concerns with developing NAPs among African countries including Lesotho, whereas awareness and training for AMR scored higher in Kenya than other African countries [72]. Implementation of IPC groups was also more advanced in Kenya, Namibia, and the United Republic of Tanzania when compared with the Democratic Republic of Congo, Lesotho, and Malawi. Namibia, Rwanda, Zambia, and Zimbabwe. These countries were also reported to be more advanced than other African countries regarding activities to optimize the use of antimicrobials in their human population, i.e., more advanced than Comoros, Democratic Republic of Congo, Gabon, Guinea, Liberia, and Sierra Leone [72]. A major concern across Africa has been the lack of documented strategies addressing key issues including hygiene, water, and sanitation [171]. The major exceptions to date regarding reporting strategies to address hygiene and sanitation among the African countries include Ethiopia, Mauritius, and South Africa [171].

While more recent published studies have documented that most African countries currently have NAPs to address AMR, there are concerns with the lack of transparency and accountability across countries [172]. This situation has not been helped by problems experienced with the preparedness among some sub-Saharan African countries, to fully tackle AMR in the first place as well as the necessary resources to fully implement their respective NAPs [8,93]. In Zimbabwe, it was estimated that investments of over US$7.5 million per year would be needed to fully fund the activities documented in their NAP [8,173], while US$21 million dollars would be needed in Ghana to implement the activities outlined in their 5-year NAP [174]. In addition, implementation of NAPs are largely donor-driven among a number of sub-Saharan African countries potentially adversely affecting the achievement of documented goals, especially if the focus of the donors change [8]. This includes available resources to develop capacities to improve AMR surveillance [93]. However, monitoring of infectious diseases has been enhanced across Africa with the recent COVID-19 pandemic [175], with such activities likely to remain.

Addressing AMR in a co-ordinated way, with sub-Saharan African countries learning from each other and developing local solutions, will provide a more robust architecture for responding to future and reemerging infectious diseases [8,139,168]. We have already seen a number of innovations being developed among African countries to deal with the recent COVID-19 pandemic providing hope for the future [175,176]. In addition, Southern African Infectious Diseases groups are coming together to co-ordinate research and push forward joint activities, including guideline development and enhanced surveillance, to improve the management of infectious diseases and reduce AMR [152,177,178].

Consequently, the objective of this paper is to document the current situation regarding ongoing activities to address rising AMR rates among a range of sub-Saharan African countries. This includes their current status alongside ongoing challenges regarding their NAPs. Subsequently, discuss how key issues are being addressed across sub-Saharan Africa to improve future antimicrobial utilization and reduce AMR. Our approach builds on the recent studies of Elton et al., Essack, Iwu and Patrick, and Harant for Africa; Engler et al for South Africa; recent studies assessing such issues across Asia; and the recent study of Munkholm et al., who ascertained that published NAPs among African countries were mostly aligned with the GAPs although cross-country learnings could be improved [72,93,166,167,172,179]. We are fully aware that implementation and monitoring of NAPs is multifaceted and typically involves a number of building blocks and key stakeholder groups within a country. Examples from Nigeria and Kenya are illustrated in Figures 1 and 2, respectively.

2. Research design and methods

We adopted a mixed methods approach, which is similar to other Pan-African projects we have undertaken to document and debate key topics, including general issues as well as

Figure 1. Building blocks to help tackle AMR in Nigeria.

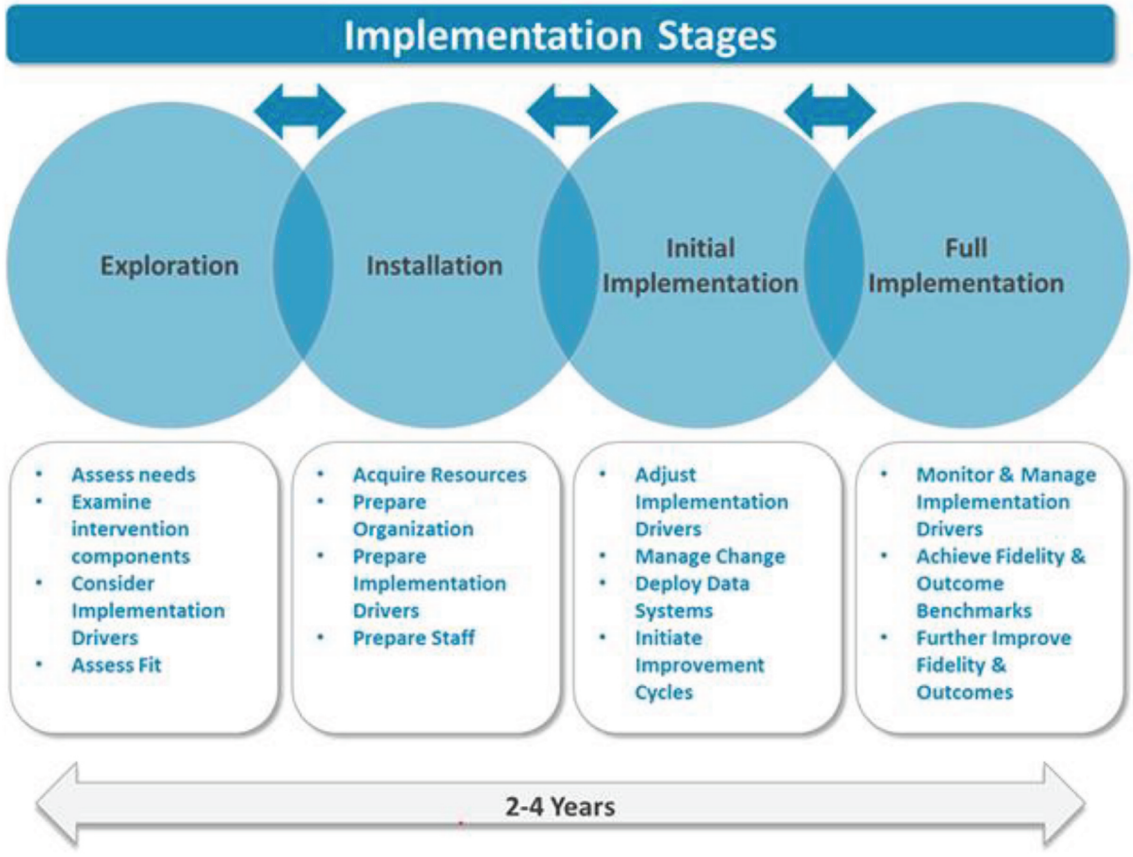

Figure 2. Implementation of the NAP and follow-up in Kenya.

important matters surrounding both infectious and noninfectious diseases [35,76,175,180–185].

The first stage involved conducting a narrative review of recent published literature regarding activities across Africa, including the development of NAPs and their status, to improve antibiotic utilization through increased knowledge, and other activities, to reduce AMR among a range of sub-Saharan African countries [72,175]. This was not a systematic review as the principal aim of this paper was to document the current situation and strategies regarding AMR and NAPs among selected sub-Saharan African countries to provide future direction. However, the documented studies, including internet publications surrounding the introduction of the NAPs in each country, were based on the considerable knowledge of the senior-level coauthors. This included individual country studies documenting current antimicrobial utilization and resistance rates across all sectors known to the coauthors from each country. We have adopted this approach before when discussing key activities and their future implications across countries and continents [14,35,76,96].

The African countries chosen were also based on the considerable knowledge of the senior-level coauthors to address the objectives of the paper and provide future guidance. The African countries were not split into either low- or middle-income African countries, or by their geography, as the issues and challenges surrounding the implementation of the NAPs were common across Africa [72,93]. Overall, the selected countries provided a range of geographies, economic status [gross domestic product (GDP)/capita] [186], and population size [187] (Table 1) in order to meet the study objectives.

The second stage involved a summary of key ongoing activities among the selected African countries for 2020/2021, building on summaries within the WHO, FAO, and OIE global tripartite database [188], combined with feedback from senior-level personnel among the various African countries (Table 2).

The final stage involved an explorative study among senior-level government, academic, and healthcare professional personnel across Africa using an analytical framework approach, combined with a pragmatic paradigm, to provide future direction [299–301].

Table 1. Current population size and GDP/capita among participating African countries.

Country	Population size	GDP/capita (US$)
Eswatini	1,160,164	3,415.5
Botswana	2,351,627	6,711.0
Namibia	2,540,905	4,211.1
Zimbabwe	14,862,924	1,128.2
Zambia	18,383,955	1,050.9
Malawi	19,129,952	625.3
Cameroon	26,545,863	1,499.4
Ghana	31,072,940	2,328.5
Uganda	45,741,007	817.0
Kenya	53,771,296	1,838.2
South Africa	59,308,690	5,090.7
Tanzania	59,734,218	1,076.5
Nigeria	206,139,589	2,097.1

The key questions following an analysis of the literature included the following:

(1) Is there a NAP in place in your country to reduce AMR? If so, when was this launched and what are the key organizations involved?
(2) What are the key objectives of the NAP (national/provincial/local) and does this include a One Health approach? Do the objectives include enhancing public awareness regarding antimicrobial use/AMR? If so, how is this instigated?
(3) How is progress toward the objectives of the NAP being measured, e.g. issues surrounding audit and feedback? What key achievements have occurred to date/what are still outstanding?
(4) What structures/activities are in place to improve appropriate antibiotic prescribing and dispensing in humans, e.g. the extent of ASPs now and in the future? What monitoring/surveillance systems are in place across sectors to monitor antibiotic use/resistance/ASP activities? How have these been implemented and any successes to date to improve future antibiotic use?
(5) What are the key challenges to implementing NAPs (national/provincial/local)/key lessons learnt? How are these being addressed?

The senior-level coauthors in each participating country were approached using a purposeful sampling methodology [302]. The coauthors collated the replies from each country, which were subsequently collated and reviewed by the principal author (BG). The initial findings were fed back to each country for review and refinement to enhance their accuracy. The final responses were subsequently analyzed using thematic analysis techniques [183,303]. Common themes were identified and subsequently discussed with the coauthors in each country to provide future direction [183]. During the initial stages of this process, pertinent points arising from the country feedback, including additional key publications, were combined with the findings from the narrative review to provide comprehensive up-to-date feedback for each country. This was seen as crucial in order to fully identify ongoing activities and challenges within each surveyed sub-Saharan African country when implementing their NAPs, with the findings used to discuss potential next steps. The findings were subsequently summarized into the key challenges faced by participating sub-Saharan African countries when implementing their NAPs, which were categorized into limited or no challenge, a challenge or a considerable challenge based on the experiences of the coauthors [304].

There was no ethical approval for this study as we did not include human subjects. In addition, the coauthors were typically technical experts in their field who voluntarily provided the information for this paper. This mirrors similar studies conducted by the coauthors across an appreciable number of African countries and wider, involving both infectious and noninfectious diseases as well as general subjects, and is in line with institutional guidance [35,76,175,180,181,183–185,305,306].

Table 2. Key activities, groups, and evaluation of progress within NAPs to reduce AMR among sub-Saharan African countries.

Country	Summary of key activities

Botswana [58,69,74,114,189,190]	• Botswana has committed to establishing a NAP (2018 – 2022) embracing the One Health approach. This was finalised in 2017; however, not currently launched as of early 2022
	• The National AMR Governance Structure (NARGS) Group will be responsible for implementing the NAP with Technical Working Groups appointed to ensure programme planning and implementation
	• NARGS will be supported by key members from sectors including human, animal, agricultural and environmental health sectors as well as key academics, developmental partners and regulatory bodies/ councils
	• Activities to create public awareness of AMR include developing and distributing relevant information as well as road shows/ radio talks and adverts on TV and the radio
	• Alongside this, ad hoc training courses on AMR with IPC committees established within hospitals as well as increased monitoring of antimicrobial prescribing in hospitals against agreed guidance including reducing the extent of continued antibiotic prophylaxis post operatively to prevent surgical site infections (SSIs)
	• Bi-annual reviews of key indicators as well as annual reviews of prioritized activities to help meet agreed goals. Key indicators include:
	  • Current antimicrobial utilisation patterns and assessed against current regulations
	  • % of healthcare facilities with IPC programmes in place as well as basic sanitation/ hygiene
	  • External quality assurance for laboratories participating in GLASS
	  • Functioning DTCs/ AMS groups within facilities especially public hospitals
	• Continual lobbying of the Government and donors to secure necessary resources to achieve agreed goals
	• Future quality indicators will involve monitoring utilisation based on the WHO AWaRe classification

Cameroon [191-194]	• Currently only a limited number of hospitals in Cameroon have AMS groups, AMR surveillance structures, or IPC committees with currently no national IPC programme in place • In addition, currently limited diagnostic capacity in Cameroon leading to high empiric use of antibiotics with no action plan currently for routine surveillance. This is not facilitated by limited funds currently being allocated to healthcare to improve the situation • The NAP for AMR addressing the 5 key strategic elements (Box 1) was launched in 2018 to 2020, with AMR evolving from the sulphonamides in Cameroon the 1930`s to daptomycin in the 1950s and continuing. • Some priority actions were identified in the NAP including the creation of awareness on the effect of AMR on health through mass communication programmes and education of stakeholders involved in the fight against AMR, establishing a surveillance system for AMR, and improving the laboratories/ capacity building to effectively detect resistant germs and reduce the incidence of infections by applying effective measures including AMS programmes to prevent resistant infections • However, there are concerns with the implementation of key activities in the NAP including currently limited training regarding AMR across the country, especially given current high resistance rates to antimicrobials of clinical relevance in Cameroon. This needs to be addressed going forward

Eswatini [195,196]	• The final draft of the NAP was made available at the end of 2017, with the Government of the Kingdom of Eswatini highly committed to curbing the spread of AMR in the Kingdom. The strategic objectives are in line with the WHO objectives (Box 1).
	• With support from the Fleming Fund, the implementation plan of the NAP has been instigated with the following objectives:
	  • Translate the strategic objectives of the NAP into activities and actions.
	  • Align the implementation plan with existing policies, regulations, and guidelines, and identify opportunities for improvement.
	  • Facilitate national coordination of the implementation of AMR surveillance strategies in the different sectors.
	  • Monitor the implementation plan outputs and collating experiences for future adjustments.
	• A multi-sectoral collaboration of different ministries within the country is now underway to promote a One Health approach to address concerns with current AMR rates in Eswatini. Key activities include:
	  • Strengthening of the governance and leadership of the AMR containment committee (AMRCC) to oversee and monitor AMR, antimicrobial use (AMU), and antimicrobial consumption (AMC) across sectors.
	  • Improving capacity for AMR and AMU/AMC surveillance across sectors; the human and animal health sectors and the environment
	  • The development of materials to help standardize operating procedures and protocols, enhance laboratory bench aids and improve national data flow systems in compliance with the WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS).
	  • Instigation of monitoring and evaluation (M & E) activities including a plan to measure the progress of the strategic objectives. The coordination of the M& E will be carried out by the antimicrobial resistance containment committee (AMRCC) under the leadership of the One Health Committee (OHC) which is composed of senior officials from the three key ministries.
	• Some data on antimicrobial utilisation (AMU and AMC) patterns and AMR is currently available in Eswatini. This will grow as more studies are undertaken, including PPS studies

(*Continued*)

Table 2. (Continued).

Country	Summary of key activities
Ghana [35,63,64,70,80,175,197-211]	• The Ghana NAP (2017 – 2022) was launched in 2017 incorporating multiple stakeholders building on comprehensive AMR Platform Membership from 2011 onwards, with published studies showing the considerable economic impact of inappropriate antibiotic prescribing alongside general studies showing the impact on morbidity and mortality • The key objectives were in line with strategic objectives of the WHO NAP (Box 1), with national IPC programmes and other programmes in place. In addition, creating an enabling environment for sustainable investment in Ghana to help fund new diagnostic tools, vaccines and new medicines to meet the growing unmet need • Active monitoring of agreed strategic activities as part of the NAP including AMR monitoring using specific indicators that have been developed under each strategic objective and sub-objective of the NAP - specifying the data sources that inform each indicator or where data for the indicator can be obtained and targets for the stated indicator. In time, greater use of the AWaRe classification for antibiotics to enhance the future quality of antimicrobial prescribing given current concerns across sectors and populations. This is helped by a strong political will to reduce AMR in Ghana enhanced by increasing co-operation among key stakeholders • There have also been studies assessing the impact of delayed prescribing of antibiotics for patients with upper RTIs in ambulatory care, with such activities likely to grow as this reduces over-prescribing of antibiotics • However, there are concerns with available resources to fully implement the documented strategies although Ghana has been successful in obtaining donor support and working with groups in different countries to improve the use of antimicrobials across sectors through educational and other initiatives. There is still room for improvement as seen by concerns with adherence to guidelines for the management of community acquired pneumonia as well as the management of febrile outpatient in recent studies in Ghana • Overall, Ghana has made appreciable progress towards including AMR as a key area within existing programmes and divisions. This includes nationwide, government-supported AMR awareness campaigns targeting the majority of priority stakeholder groups in Ghana, with prescribing practices increasingly monitored in hospitals and the community. However, there are concerns that no standardized national AST guidelines are currently in place, and with available resources for hospitals to purchase the necessary diagnostic equipment to regularly conduct diagnostic testing and produce up-to-date antibiograms for hospitals to guide empiric prescribing. There are also concerns regarding the extent of IPC activities within hospitals in Ghana • These activities have been aided by Ghana hosting the second Global Call to Action on AMR, ongoing surveys to monitor outpatient prescribing against treatments recommended in the National Medicines Policy Guidelines as well as the development of electronic applications (Apps) as learning resources to improve future antibiotic prescribing
Kenya [103,104,164,212-231]	• The Ministry of Health and Ministry of Agriculture, Livestock, Fisheries and Cooperatives, and other key stakeholders, launched the Kenyan NAP in 2017 with strategic objectives in line with the WHO NAP (Box 1) with implementation over a number of years including dissemination of AMR data (Figure 2) • Regular education and awareness activities with annual AMR awareness events held over the last seven years to address AMR concerns. These efforts are guided by the National Communication Strategy on AMR and are accompanied by Information Education and Communication materials including a National One Health Training Curriculum. This consistency resulted in Kenya hosting the first Regional World Antibiotic Awareness Week in 2019 • These activities build on growing concerns with rising AMR, rates across Kenya. They include establishing sentinel AMR surveillance sites as per the National AMR Surveillance Strategy as well as encouraging studies to improve key stakeholder knowledge of current antimicrobial utilisation and resistance patterns across sectors through a National AMR Surveillance Network as well as studies on AMS activities • The National AMR Database, which is a One Health platform, is hosted within the Ministry of Health in Kenya. This helps ensure laboratories across Kenya use the same AST guidelines enforced through a standard one health training course on antimicrobial resistance. The surveillance sites are actively contributing AMR data to the National AMR surveillance system by implementing Surveillance Strategies developed for Human and Animal Health. • To support Infection Prevention and Control, Water, Sanitation and Health, there exists a functional National IPC Programme with a guiding Policy and Strategy for IPC. Ongoing activities include strengthening national and regional IPC leadership and governance structures to support the implementation of the National IPC Policy and Strategy - adopting a continuous quality improvement approach to implementation for sustainability. For animal health the inclusion of hygiene and IPC as a core component of training and education for veterinary professionals is ongoing. • In optimising the use of antimicrobial agents, Kenya has developed strategies to optimize and regulate the use of antimicrobials through the development and implementation of Guidelines for the Prudent Use of Antimicrobials in Animals, National AMS guidelines for Healthcare Settings, a National Integrated AMS Plan and more recently the Clinician's Handbook on Diagnostic Stewardship to bridge the gap between the laboratory and the clinical teams. In addition to instigating national AMS guidelines, efforts have been augmented by the development of the first pre-service curriculum on antimicrobial stewardship. • The NAP implementation process was further strengthened in 2021 through the development of a more comprehensive monitoring and evaluation framework to track progress over time. • Overall, the national coordinating mechanisms and supporting technical working groups are seen as functional with clear terms of references and regular meetings to enhance successful implementation of agreed activities to reduce AMR

(*Continued*)

Table 2. (Continued).

Country	Summary of key activities
Malawi [32,232-235]	• The Malawi NAP is a critical component of the Health Sector Strategic Plan II (HSSPII) running from 2017 to 2022, building on HSSPI, which ran from 2011 to 2016. The NAP provides a detailed operational plan building on the WHO strategic objectives (Box 1) and involves all key Ministries within Malawi, with ongoing investment from the Fleming Fund to help improve surveillance in the country to improve future antimicrobial use • The key oversight functions of agreed AMR activities are being managed by the Ministry of Health through the AMR National Coordinating Centre, with the NAP now being implemented. There is also ongoing ad hoc training regarding AMR among key groups • The Ministry of Health through the AMR National Coordinating Centre has also established the agenda for AMR surveillance among hospitalised patients and those in ambulatory care in Malawi in collaboration with key stakeholder groups given ongoing concerns. However, major modifications in the AST and bacterial isolation protocols used are required to improve their adaptation to meet national AMR surveillance objectives • There are concerns though with the routine availability of essential antibiotics especially in rural settings, which may undermine attempts generally to improve antimicrobial utilisation in ambulatory care in Malawi • Alongside this, there are also concerns with high use of broad-spectrum antibiotics within hospitals in Malawi with infrequent use of blood culture testing to improve prescribing. This is because whilst there are trained lab personnel in Malawi, very few facilities are able to undertake blood cultures, bacterial isolation and AST. The majority of district hospitals have to rely on full blood counts to support their diagnosis and prescribing leading to high broad spectrum antibiotic prescribing
Namibia [11,82,122,123,131,172, 236-238]	• There have been ongoing activities across Namibia to improve antimicrobial use including activities by USAID funded projects (SIAPs). • This includes a pharmaceutical management information system for monitoring of antimicrobial prescribing across sectors against agreed guidance to improve future antimicrobial use, with good adherence rates to guidelines in Namibia enhanced by easy access to up-to date objective guidelines with ease of referencing as well as support systems for continued education regarding their use • Alongside this, monitoring antibiotic sensitivity patterns in hospitals • The NAP for AMR has also been developed to guide prescribing and surveillance activities in Namibia; however, still awaiting government approval. The NAP includes educational and other activities; however, the routine collection of AMR data could be improved with currently no standardised national AST guidelines • Encouragingly, the national standard treatment guidelines have been revised in 2021 to ensure that antibiotic choices are aligned to current resistance patterns and accessibility. There is also a dedicated unit within the directorate of pharmaceutical services to coordinate activities surrounding AMR and rational use of medicines • Alongside this, the interest group NABIAN Against Antimicrobial Resistance (NAAR) have recently developed a guideline for antibiotic use, among other activities. In addition, existing policies restrict or control of antibiotic use in food animals • The was considerable pro-activity among community pharmacists at the start of the recent COVID-19 pandemic to guide appropriate prevention and treatment, with community pharmacists in Namibia aware of the current regulations not to dispense antimicrobials without a prescription. This is continuing

Nigeria [62,84-86,147,239-251]	• The production of the Nigerian NAP was led by the Nigeria Centre for Disease Control (NCDC) in collaboration with key Federal Agencies, Development partners, Academia, Healthcare institutions, and the private sector, and was launched in November 2017
	• The AMR structure implementing and monitoring activities comprises the Antimicrobial Resistance Coordinating Committee (AMRCC), the National AMR -Technical Working Group (NAMR-TWG) including stakeholders from all the key areas and divided into 5 pillars addressing key strategic implementation areas in line with the Global NAP (Box 1)
	• The AMR governance structure adopted the One Health approach reporting to the National One Health Steering Committee (NOHSC) through the National One Health Technical Committee (NOHTC) involving the Director General of NCDC as well as the Chief Veterinary Officer of Nigeria. This is essential given concerns with current resistance rates in Nigeria across sectors as well as health care-associated infections (HCAIs), with mobilisation of resources ongoing to help achieve agreed objectives and goals
	• There are continuing issues regarding the knowledge of healthcare workers in Nigeria regarding AMR, ASPs and information regarding antibiotics provided by independent sources; however, this is likely to change with ongoing implementation of the NAP. In addition, pertinent quality improvement programmes to enhance appropriate antibiotic prescribing across sectors as knowledge levels grow through point prevalence and other studies
	• Progress of the NAP is being regularly monitored via Independent Joint External Evaluation of International Health Regulation (IHR) Core Capacities as well as quarterly meetings of the National AMR- Technical Working Group/ AMRCC
	• Key achievements to date include (but not limited to):
	  • Establishment of National Reference Laboratories for AMR in human and animal health along with 35 human health (11 optimized presently) and 6 animal health sentinel laboratories across the country with support of groups including the Fleming Fund Country Grant along with laboratory capacity building programmes, with additional surveillance sites being added
	  • Routine AMR surveillance data collection across the country and reporting to the Global Antimicrobial Resistance Surveillance System (GLASS) through the NCDC. This should help standardise approaches across the country
	  • IPC guidelines developed along with the 'Turn Nigerian Orange (TNO) initiative' to help health facilities become IPC centres of excellence.
	  • Establishment/ strengthening of ASP activities in 10 tertiary hospitals selected as AMR surveillance sites to develop AMS action Plans and conduct PPS studies with support from the Fleming Fund Country Grant. This including launching AMS committees in four of these sites
	  • Commencement of a National Community of Practice on AMR and antimicrobial use to enhance awareness of AMR among healthcare professionals

(*Continued*)

Table 2. (Continued).

Country	Summary of key activities
South Africa [59,61,65,66,81,94,117,124,178,190,252-270]	• Integrated approaches have been used to progress the NAP in South Africa following its launch in 2017, and now in its second edition, with a co-ordinated One Health approach helping to improve antimicrobial utilisation and reduce resistance, e.g., concerns with rising resistance to colistin resulted in co-ordinated activities to reduce its use in animals as well as improve appropriate use among patients • The NAP is being actively monitored through a standard monitoring and evaluation framework, which will continue • Alongside this, active measuring of compliance against South Africa's AMR strategy among healthcare facilities across South Africa including hospitals • In addition, increased surveillance of AMR patterns across South Africa co-ordinated by the Ministry of Health as a key monitoring target within the NAP along with co-ordinated activities to improve IPC activities within healthcare facilities. This includes the development and dissemination of IPC guidelines, including their practical implementation, to raise awareness of AMR among all key stakeholder groups and ways to address key concerns. However, there are currently no standardised national antimicrobial sensitivity testing (AST) guidelines in place to improve surveillance, which need to be addressed • There are an increasing number of studies being undertaken across sectors in South Africa to monitor current antimicrobial prescribing against agreed guidance given identified concerns, with the findings used to develop pertinent quality improvement programmes. This increasingly includes the use of specially developed Apps as well as the instigation of ASPs across hospitals to address identified concerns • Alongside this, a number of pilot ASPs have been initiated in primary health care centres in the public sector to improve future antimicrobial use alongside investigating potential point-of-care testing in primary care for common infections. In addition, whilst AMS curriculum changes have been implemented at all pharmacy schools in South Africa, a subcommittee of the Ministerial Advisory Committee (MAC) for AMR is currently spearheading undergraduate changes at medical schools to enhance knowledge among undergraduates given current concerns. This is important with healthcare professionals in a recent study indicating the need for further training regarding antibiotics, AMR and AMS programmes to improve future prescribing, as well as concerns with the implementation of ASPs in line with the national AMR strategy • Whilst the Department of Health and others have launched the Antibiotic Guardian campaign, there are ongoing concerns with public awareness of AMR in South Africa as rates continue to rise. In their recent study, Mokoena et al (2021) documented several misconceptions regarding antibiotics and their role among the minibus-taxi community. The study also highlighted the urgent need to standardise a common reference for antibiotics and resistance across linguistic barriers nationally. Identified enablers for public awareness and empowerment going forward included targeted public awareness campaigns • There are also potential concerns regarding the dispensing of antimicrobials without a prescription, which need urgent exploration in future studies
Tanzania [63,83,271-274]	• The NAP for Tanzania (2017 – 2022) involving all key Government Departments and incorporating the 5 Strategic Objectives of the Global NAP (Box 1) was launched in 2017 • There are concerns with high and empiric use of antimicrobials among hospitals although encouragingly most prescribing has been from the Access Group and generally with high adherence to the Tanzania STGs although not universal • In addition, concerns with extended prophylaxis to prevent SSIs among some hospitals in Tanzania leading to calls to enhance ASPs within the country. This is important with a recent study suggesting that hospital antibiotic policies were only present in 15.4% of health facilities surveyed, with only 17.9% regularly conducting prescribing audits and a similar number microorganisms susceptibility testing • Greater educational activities can enhance knowledge of the NAP among health facilities with only 66.7% of personnel among surveyed facilities aware of the NAP • This is already starting with the development of electronic Apps as learning resources to improve future antibiotic prescribing
Uganda [63,275-286]	• The NAP for Uganda (2018 – 2023), which involved all key Government Departments and incorporated the 5 Strategic Objectives of the Global NAP (Box 1), was developed with assistance from the Ugandan National Academy of Sciences and CDDEP's Global Antibiotic Resistance Partnership (GARP). The Fleming Fund was also involved in the development and dissemination of the NAP • This is in response to high levels of resistance to commonly prescribed antimicrobials in Uganda. This is enhanced by over prescribing and dispensing of antibiotics across sectors including dispensing without a prescription, lack of diagnostic tools and over use in farming, driving up the improper use of antimicrobials across sectors, with polypharmacy being a big driver of improper use and abuse of antimicrobials • Multifunctional groups appear to be working in Uganda implementing the NAP with reporting/accountability arrangements defined, as well as developing and implementing functional AMR surveillance strategies. Alongside this, electronic Apps have been developed as learning resources to improve future antibiotic prescribing across Uganda, given current concerns with compliance to current guidelines. Such activities are likely to grow given current challenges, including issues of ownership • However, there are concerns that whilst some AMR data is being collected, there is no standardized approach affecting interpretation. National coordination and/or quality management is also lacking with major modifications needed for AST, bacterial isolation and identification protocols to attain national AMR surveillance objectives

(*Continued*)

Table 2. (Continued).

Country	Summary of key activities

Zambia [63,87,287-292]	• The NAP was launched in 2017 involving all key stakeholder groups, including line government ministries, and incorporating the strategic objectives outlined in the WHO National Plan (Box 1). More recently, the integrated AMR surveillance framework has been launched - building on active surveillance of AMR in both human and animal health
	• Along with this, a multisectoral national Antimicrobial Resistance Coordinating Committee (AMRCC) oversees and regularly monitors activities to achieve desired objectives contained within the NAP for AMR given concerns with current antimicrobial usage patterns and practices
	• ASPs are currently being piloted in 7 healthcare facilities along with pieces of training on AMR and ASPs within in-service continuing education and pre-service training programmes for healthcare professionals
	• The AMRCC is also monitoring stewardship interventions and antimicrobial use via PPS studies
	• A national IPC programme is in operation and national guidelines for IPC committees are available and are being actively disseminated, with increased co-ordination of AST facilities to better track resistance patterns and develop local antibiograms especially in hospitals
	• An AMR surveillance network has now been established with 5 laboratories regularly submitting data to the WHO GLASS (from 1 in 2016) along with more capacity building for surveillance in human and animal health
	• Additional achievements include:
	  • Mainstream media (both electronic and print) regularly covering AMR topics
	  • AMR and AMS topics now part of undergraduate training for healthcare professionals
	  • Electronic Apps have been developed as learning resources to improve future antibiotic prescribing
	  • Undertaking baseline PPS studies across Zambia (11 facilities) with 4 additional sites added with help from WHO and other collaborating partners. In addition, planning PPS studies in Level 2 hospitals
	  • Baseline data on IPC activities being collected in 11 facilities according to international methodologies

Zimbabwe [8,173,234,293-298]	• The NAP for Zimbabwe was launched in 2017 and runs until 2022 involving all key stakeholder groups and incorporating the strategic objectives outlined in the WHO National Plan (Box 1) • The NAP has been implemented with multi-sectorial groups working together with clear terms of reference and monitoring of activities to push forward agreed goals • This is seen as essential given concerns with high resistance rates to common antibiotics in Zimbabwe. However, there are concerns with available resources to fully fund all listed activities in the NAP without additional support from donors and other organisations • There is ongoing support from the Fleming Fund and others to improve antimicrobial surveillance and capacity in Zimbabwe and reduce AMR. This will be achieved through upscaling the laboratory sector and upgrading two reference laboratories in the human health and animal • The human health National Microbiology Reference Laboratory AMR Unit has already been commissioned to conduct antimicrobial sensitivity testing. In addition, a national IPC programme and operational plan are available, with national guidelines for IPC activities within healthcare facilities available and disseminated • The Government has recently secured a grant of US$1million Antimicrobial Resistance (AMR) MULTI-PARTNER TRUST FUND to promote the use of vaccines across sectors, strengthen the National IPC programme by supporting a pilot surveillance system of HAIs in selected health facilities and conduct studies to better understand key drivers of AMR in different stakeholder groups to develop specific behaviour change intervention targets • There are also ongoing strategies to raise awareness and address concerns with the prescribing of antibiotics across sectors to reduce future AMR rates

NB: Includes summaries within the WHO, FAO, and OIE global tripartite database; AMR, antimicrobial resistance; AMS, antimicrobial stewardship; ASP, antimicrobial stewardship programme; AST, antimicrobial sensitivity testing; CST, culture sensitivity testing; GLASS, Global Antimicrobial Resistance and Use Surveillance System; HAI, healthcare-associated infections; IPC, infection, prevention, and control; NAP, national action plan; PPS, point prevalence survey.

3. Results

3.1. Current status of NAPs and the monitoring of activities

We will first document the current situation regarding the NAPs in each selected African countries. This includes current structures and activities, as well as ongoing monitoring and evaluation of continuing activities, to achieve agreed target objectives and goals. This will be followed by a summary of key identified challenges regarding the implementation of the NAP across countries and how these are currently being addressed to provide future direction.

All surveyed sub-Saharan African countries have developed country NAPs (Table 2). However, implementation of the NAPs varies across Africa. NAPs are currently not launched in some of the included African countries, including Botswana and Namibia, just launched in others including Eswatini and further ahead in several African countries including Ghana, Kenya, Nigeria, South Africa, and Zambia.

3.2. Current challenges and how these are being addressed

Table 3 summarizes the key challenges seen among the various sub-Saharan African countries when trying to implement their NAPs. These include inadequate regulatory enforcement as well as logistics and other personnel to translate the ambitions in the country NAPs into necessary activities to achieve agreed targets. These issues and concerns are often exacerbated by a lack of adequate finances in reality.

Other identified issues and concerns with implementing country NAPs included the lack of representation from other key ministries, including Education and Environment Ministries at NAP monitoring meetings, which compromises delivering agreed multisectoral initiatives. Agreed targets and activities are also being hampered by concerns with their co-ordination at national and local levels. Partner coordination and support including from donors is often not well streamlined, again compromising attaining the ambitious targets within NAPs. There can also be a disconnect between public, private, and

Table 3. Summary of key challenges among sub-Saharan African countries when implementing their NAPs.

	Available personnel including dedicated secretariat	Concerns with focal points for monitoring activities/co-ordinating activities	Capacity (surveillance laboratories)	Available funding	Competing demands/ priorities including donors	Challenges with inter-sectoral synchrony	Expertise/ knowledge/ activities regarding AMR/ AMS/ AMU
Botswana	√√	√√	√√	√√	√√	√√	√√
Cameroon	√√	√√	√√	√√	√√	√√	√√
Eswatini	LC	LC	LC	√	√	√	LC
Ghana	LC	LC	LC	√	√	LC	√
Kenya	LC	LC	√	√√	√	LC	LC
Malawi	√√	√√	√√	√√	√√	√√	√√
Namibia	√	LC	√	√	√	√	LC
Nigeria	LC	LC	√	√	√	√	√
South Africa	LC	√	LC	√ √	√	√	LC
Tanzania	√√	√√	√√	√√	√√	√√	√√
Uganda	√√	√√	√√	√√	√√	√√	√√
Zambia	LC	LC	√	√√	√√	LC	√
Zimbabwe	√	√	√	√	√	√	√

NB: √ = a challenge; √√ = a considerable challenge. LC, limited or no challenge.

industry alignment of AMR activities, which needs to be addressed going forward.

Box 2 summarizes key activities being undertaken among surveyed sub-Saharan African countries to address current NAP challenges (Tables 2 and 3).

4. Discussion

High rates of AMR across sub-Saharan Africa, with the subsequent impact on morbidity, mortality, and costs, emphasize the importance of rapidly implementing NAPs and monitoring their progress [6,35,133]. It was encouraging to see that all the sub-Saharan African countries surveyed had made progress with constructing and implementing their NAPs. However, some countries are more advanced than others. For instance, Namibia is currently awaiting approval to start implementing their NAP while Botswana will shortly be launching their NAP. Alongside this, countries including Eswatini have just begun their NAP journey. This compares with Ghana, Kenya, Nigeria, South Africa, Uganda, Zambia, and Zimbabwe, which are further ahead with their NAPs, including regular monitoring of agreed activities. Countries including Cameroon are also further ahead with their NAP compared with Namibia and Kenya; however, there are concerns with their implementation arising from key issues, including knowledge and training regarding AMR.

It was also encouraging to see there is active monitoring of antimicrobial utilization patterns across sectors among the various sub-Saharan African countries. This includes PPS studies in hospitals as well as seeking greater knowledge of resistance patterns through WHO-GLASS and other activities. Both activities are essential to develop and instigate pertinent quality improvement programs as part of ASPs to improve future prescribing and dispensing of antimicrobials. However, ASP activities are variable across sub-Saharan Africa, and their effectiveness is influenced by available resources, personnel, and knowledge within countries [35,85,88]. Among the sub-Saharan African countries assessed, South Africa appears to have made greatest strides with the implementation of activities to curb AMR across sectors including regular monitoring activities with the implementation of their NAP as well as multiple ASP and other activities [65,307–311]. However, there is still room for improvement [94]. We are also seeing greater use of the AWaRe classification of antibiotics, to facilitate the assessment of the quality of antimicrobial prescribing, alongside greater instigation of IPC programs and activities as well ASPs across countries. These activities will continue as progress is made. This includes the development of potential quality indicators in ambulatory care across Africa building on the AWaRe classification and guidelines.

The challenges with implementing NAPs appeared similar among African countries. Key challenges included a lack of personnel including secretariat personnel to drive forward agreed NAP activities. This accentuates challenges with inter-sectoral synchrony. In addition, there are major issues with available funding, including from donors, to fully implement agreed activities alongside competing demands for scarce resources. The situation has been made worse by the recent COVID-19 pandemic and its unintended consequences which also need to be addressed [175]. Unintended consequences include reduced immunization, especially among children [45,47,49], as well as the management of patients with non-communicable diseases (NCDs) who were not properly monitored and treated during the pandemic due to lockdown measures. As a result, also increasing morbidity, mortality, and costs unless adequately addressed [312–315]. This needs to be acknowledged since if unchecked, undue focus on improving the management of patients with NCDs may divert scarce resources away from implementing agreed NAP activities.

Finally, there are recognized issues and challenges with expertise and knowledge regarding AMR and ASPs across sub-Saharan Africa. However, this is beginning to change with increasing educational and implementation activities, including Apps for electronic prescribing, to improve future prescribing coupled with calls to improve qualitative research in this area [63,310,316–319]. Furthermore, there are a number of ongoing initiatives across sub-Saharan Africa to address current challenges including general and specific activities to progress NAPs (Box 2). Such activities will continue given the high and growing rates of AMR across sub-Saharan Africa as

Box2. Summary of key activities to address current challenges

(A) Implementation – general

- While African countries are all aware of the key issues necessary to reduce rising AMR rates, there is increasing recognition that the various sub-Saharan African countries do have different capability levels including variable technical and expert advice to enact the agreed NAPs
- Increasing recognition that the different sub-Saharan African countries are willing to engage with donors and others to try and meet agreed NAP goals. This includes working with donors to secure future funding to improve AMR surveillance activities as well as assistance with implementing the findings from local/regional antibiograms to improve empiric prescribing
- Improving articulation and communication of agreed activities among all key partners including greater transparency. This includes a deliberate coalition of people, partners, and the country to translate envisioned priorities into reality to inform real-world decisions to help focus resources, ensure accountability, and have impact
- Enhancing engagement for end-to-end processes (from design to implementation) to improve joint ownership among key groups as well as enhance effective implementation and sustainability of agreed activities

(B) Implementation – specific

- Introduction/expansion of the education of all healthcare professionals including veterinary and plant health officers regarding antimicrobials/AMR/ASPs in undergraduate curricula with continuing education post qualification as well as using import and export data to improve knowledge of current antimicrobial consumption across all key sectors
- Collecting baseline data on IPC to improve future activities within hospitals. Alongside this, increasingly undertaking PPS/additional PPS studies with key stakeholders to ascertain areas for future quality improvement programs across sectors. This includes monitoring prescribing against agreed guidance – increasingly adopting the WHO AWaRe classification for antimicrobials as part of performance indicators. Potential targets for AMS programs include reducing antimicrobial prescribing post surgery to reduce SSIs
- Developing electronic Apps and other tools to shorten the time taken to undertake/ analyze PPS where pertinent as well as monitor the impact of pertinent quality improvement programs emanating from PPS studies
- Orienting and equipping multidisciplinary healthcare teams regarding the introduction of ASPs in hospitals, secure funding for instigating ASPs as well as monitoring their implementation and outcomes. Similarly, initiating pilot studies regarding implementing ASPs in primary healthcare centers given current appreciable inappropriate prescribing of antimicrobials in ambulatory care exacerbated by the recent COVID-19 pandemic, with increased use of the WHO AWaRe classification as part of agreed quality indicators
- Undertaking studies among community pharmacies to track the extent of inappropriate dispensing of antibiotics without a prescription and suggesting potential ways forward to reduce such activities building on positive experiences within African countries
- Develop context-specific, validated scales, and survey tools to evaluate healthcare workers' and the public's attitudes, motivations, and expectations regarding antibiotic use and to use these tools in the long-term evaluation and monitoring of public health programs and interventions to reduce AMR
- Instigate interventions to ensure adequate access to facilities and targeting healthcare workers and the public to ensure confidence in vaccines, high vaccination coverage, and combat vaccine hesitancy where concerns currently exist. Alongside this, improving supply chains to reduce the potential for shortages of key antimicrobials and vaccines as well as improve monitoring and other activities to help curtail the availability of sub-standard antimicrobials especially in ambulatory care
- Introducing legislation and increasing surveillance regarding antimicrobial use in other key sectors including animal and plant sectors. As part of this, increasing the involvement of the agricultural and environmental sectors to achieve a One Health–based unified approach towards combating AMR
- Improving knowledge of current antimicrobial use in animal, agriculture and plant sectors as well as resistance patterns

NB: AMR, antimicrobial resistance; AMS, antimicrobial stewardship; ASP, antimicrobial stewardship programme; AST, antimicrobial sensitivity testing; IPC, infection, prevention, and control; NAP, national action plan; PPS, point prevalence survey; SSI, surgical site infections; WHO, World Health Organization

well as the economic costs [6,142]. Consequently, urgent actions are needed across sub-Saharan Africa to reduce high AMR rates. This will increasingly include social media outlets addressing concerns with often limited involvement of key healthcare workers [321,320]. Such actions will be the responsibility of all key stakeholder groups going forward, including donors.

We are aware that there are several limitations with this paper. First, similar to our approach in previous papers, we did not undertake a systematic review as the main aim of this paper was to document the current situation and strategies regarding AMR and NAPs among a number of sub-Saharan African countries to provide future direction. As such, we did not include all sub-Saharan African countries just those where the coauthors were able to provide considerable input to meet the study objectives. We also did not categorize sub-Saharan African countries by geography or GDP as we believed the challenges applied to all sub-Saharan African countries and our objective was to consolidate current information and guidance. Furthermore, we recognize that the feedback and potential ways forward are not always based on published studies. However, to address this concern, we have included senior-level personnel, who are extensively involved with issues of antimicrobial utilization, AMR and ASPs in their countries. Despite these limitations, we believe our findings and suggestions are robust and provide future direction.

5. Expert opinion including potential ways forward

There is increasing recognition among all key stakeholders, including donors, in sub-Saharan African countries that AMR is an increasing concern that must be adequately addressed through a co-ordinated NAP approach involving all sectors, which includes humans, animals, and agriculture. However, while all surveyed sub-Saharan African countries had developed their NAPs, they are at different stages of implementation. These range from shortly looking to implement country NAPs to regularly monitor agreed activities within country NAPs to reduce AMR. Current challenges to implementing NAPs include the lack of available personnel, expertise, and funds. Challenges also include issues of capacity including surveillance, competing demands for scarce resources as well as concerns with inter-sectoral synchrony. It is likely we will see these challenges being addressed over the coming years across sub-Saharan Africa with the support of donors and others to improve surveillance and other activities. In addition, articulation and communication of agreed activities will improve to reach stated goals. Alongside this, enhancing engagement among all key stakeholders for end-to-end processes to improve ownership and implementation of NAPs to achieve desired ends.

Specific activities to help achieve desired goals within country NAPs include expansion of educational activities within university curricula and post-qualification among key healthcare groups. We

will also likely see IPC programs becoming a routine part of all hospital activities. PPS studies and other activities will also be routinely undertaken in hospitals to identify potential interventions to further enhance the rational use of antibiotics within hospitals. Potential targets in hospitals for quality improvement programs include greater documentation regarding the rationale behind the chosen antibiotics, reducing extended prophylaxis for antibiotics administered to reduce SSIs in patients undergoing surgery, greater adoption of the WHO AWaRe classification as part of potential quality indicators, and increased monitoring of adherence to agreed guidelines when antibiotics are administered. This includes greater monitoring of prescribing of antibiotics from the WHO Watch list. Greater use of electronic technology including Apps will assist with routine surveillance and assist with appropriate responses to reduce hospital acquired antibiotic-resistant infections.

There will also be growing introduction of ASPs within ambulatory care to address inappropriate prescribing of antibiotics in this key sector, especially for potentially self-limiting conditions such as ARIs. Potential quality targets include the percentage of patients prescribed an antibiotic for an ARI and the nature of any antibiotic prescribed. The dispensing of antibiotics without a prescription is also an increasing concern across Africa, with increasing activities likely to address this. Potential activities include greater education of patients and community pharmacists, as well as regular monitoring of community pharmacies to enhance their compliance with any regulations. Different mass media sources will also be increasingly used to educate patients regarding the harms associated with AMR and ways to reduce this. Mobile telephones, and other technologies, will also be increasingly used to track dispensing of antibiotics. Alongside this, increasing monitoring of the availability of sub-standard antibiotics, with associated activities to curtail their availability, as part of community activities to reduce AMR.

Lessons from the current COVID-19 pandemic will lead to the instigation of educational and other activities to ensure continued high rates of pertinent vaccinations to reduce future infectious diseases, and with this inappropriate antibiotic use and AMR. This will necessarily entail interventions targeting healthcare professionals and patients to address vaccine hesitancy as well as ensuring vaccination programs continue during future pandemics. This can involve the use of mobile clinics and other community service points, e.g. pharmacies, if accessing hospital clinics is a challenge. This ensures the situation seen when lockdown and other measures were first introduced to curb the spread of COVID-19 is not repeated. These activities recognize the important role of vaccination policies, communication, and demand creation in preventing infectious diseases, inappropriate antibiotic utilization, and the development of AMR.

Declaration of interest

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