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Short Report

A One Health approach to fight antimicrobial resistance in Uganda: Implementation experience, results, and lessons learned

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ABSTRACT

Uganda has been implementing the Global Health Security Agenda (GHSA) since 2015 to build its capacity according to *World Health Organization (WHO) Benchmarks on International Health Regulations Capacities*. The country remains prone to outbreaks, with more than 20 disease outbreaks reported in the past five years, including Ebola virus disease, Crimean-Congo haemorrhagic fever, Marburg haemorrhagic fever, measles, yellow fever, coronavirus disease 2019 (COVID-19), and cholera. Antimicrobial resistance (AMR) is an ongoing challenge. Uganda scored capacity level 3 on infection prevention and control (IPC) and antimicrobial stewardship (AMS) in the 2017 Joint External Evaluation (JEE) assessment. Identified gaps were being addressed after a self-assessment in 2021. This paper describes the technical assistance approaches provided to Uganda by the Medicines, Technologies, and Pharmaceutical Services Program, funded by the United States (U.S.) Agency for International Development, and implemented by Management Sciences for Health. The program, through a One Health approach, supported systematic capacity strengthening based on the JEE's capacity advancement framework for global health security, specifically relating to AMR. The program's interventions impacted 32 WHO benchmark actions (7 for AMR multisectoral coordination, 16 for IPC, and 9 for AMS), contributing to Uganda's strengthened GHSA capacity. Leveraging success built on the AMR platform, the program trained 745 health workers in IPC for the Ebola virus and provided support for simulation exercises by eight district IPC teams. The program also worked with the Ministry of Health to coordinate IPC for the COVID-19 response in five health regions, covering 45 districts and reaching 5,452 health workers at 858 health facilities.

1. Introduction

Emerging and re-emerging infectious diseases pose a threat to global health security, with the potential to reverse global public health gains [1]. The socioeconomic and public health ramifications of pandemics are devastating [2]. For example, the coronavirus disease 2019 (COVID-19) pandemic led to more than 7 million deaths and massive global economic loss, and was associated with the emergence and transmission of resistant pathogens [3,4]. The burden of antimicrobial resistance (AMR) as a health security threat has substantially increased, with more than 4.92 million deaths associated with and 1.27 million deaths attributable to AMR in 2019 [5]. Unabated, AMR will cost the global economy more than 100 trillion dollars and lead to more morbidity and mortality than cancer by 2050 [6]. Like most infectious diseases, AMR disproportionately affects individuals

Abbreviations: AMR, antimicrobial resistance; AMS, antimicrobial stewardship; AWaRE, Access, Watch and Reserve; CME, continuous medical education; CQI, continuous quality improvement; CSO, civil society organization; EML, essential medicines list; EVD, Ebola virus disease; GHSA, Global Health Security Agenda; HH, hand hygiene; HHSAF, Hand Hygiene Self-Assessment Framework; IHR, International Health Regulations; IQR, interquartile range; IPC, infection prevention and control; IPCAF, Infection Prevention and Control Assessment Framework; IPCAT, Infection Prevention and Control Assessment Tool; JEE, Joint External Evaluation; MAAIF, Ministry of Agriculture, Animal Industry and Fisheries; MOH, Ministry of Health; MSC, multisectoral coordination; MTaPS, Medicines, Technologies, and Pharmaceutical Services; NAMRsC, National AMR Sub-Committee; NAP, National Action Plan; NGO, nongovernmental organization; RRH, regional referral hospital; SD, standard deviation; SDG, Sustainable Development Goal; TWC, technical working committee; TWG, technical working group; UHC, universal healthcare; USAID, US Agency for International Development; WASH, water, sanitation, and hygiene; WHO, World Health Organization.

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from low socioeconomic status and low- and middle-income countries [6]. The zoonotic potential of AMR and its ability to affect animal health, water, and the environment poses a threat to food security [7].

Uganda continues to face the challenge of infectious diseases, with more than 60.0 % of annual deaths attributable to infectious diseases, such as HIV, tuberculosis, malaria, diarrheal diseases, and pneumonia [8,9]. Uganda remains prone to outbreaks, with more than 20 disease outbreaks reported in the past five years, including Ebola virus disease (EVD), Crimean-Congo hemorrhagic fever, Marburg hemorrhagic fever, measles, yellow fever, anthrax, COVID-19, and cholera [10]. To better prepare and respond to these threats, countries have committed to various high-level initiatives and agreements to build global health security [11,12]. This includes sharing best practices and facilitating national capacity to comply with and adhere to the *World Health Organization (WHO) International Health Regulations (IHR), World Organization for Animal Health International Standards and Guidelines, the United Nations Security Council Resolution 1540, Biological Weapons Convention*, and other relevant frameworks that contribute to global health security [13].

Uganda has been implementing the Global Health Security Agenda (GHSA) since 2015 to build its capacity for WHO's IHR. The country has participated in a WHO Joint External Evaluation (JEE), ratified a National Action Plan (NAP) on AMR [14] that is aligned with the WHO's Global Action Plan on AMR, and is implementing a National Action Plan for Health Security [15]. Uganda scored capacity 3 on infection prevention and control (IPC) and antimicrobial stewardship (AMS) during the 2017 JEE assessment [16]. Identified gaps are currently being addressed after a 2021 self-assessment which included a score of 2 for IPC [17]. This paper describes our experiences supporting the Government of Uganda to advance the country's JEE capacity, with a focus on AMR. We share key results, lessons learned, and recommendations.

2. Materials and methods

2.1. Overview of the program

The US Agency for International Development funded Medicines, Technologies, and Pharmaceutical Services Program (hereafter called "the program"), in collaboration with national counterparts, helped implement global health security activities in Uganda between January 2019 and September 2023 (Table 1). The program's mandate was to provide technical assistance to strengthen systems and practices for IPC, for the optimal use of antimicrobial medicines, and for multisectoral coordination (MSC) to contain AMR using the One Health approach [18].

2.2. Getting started, establishing a baseline, and identifying key stakeholders

The program applied mixed methods to establish a baseline for interventions to address AMR and to inform future monitoring and evaluation of progress. The baseline situational analysis methods included: (i) an in-country scoping visit; (ii) a literature review; (iii) key informant interviews; and (iv) baseline surveys at health facilities.

The literature review and key informant interviews provided critical information about the status, gaps, and priorities of AMR activities in the country. For example, the scoping visit established that key actions under capacity levels 2 and 3 as recommended in the WHO's *Benchmarks for International Health Regulations Capacities* (WHO benchmarks) [19] had not been completed for IPC (indicators 3.3) and AMS (indicators 3.4). Key informant interviews at the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) identified the need to develop communication messages for the agriculture sector and to update the *Uganda Essential Veterinary Medicines List*. To foster the spirit of ownership, the program identified key stakeholders for collaboration and partnership to achieve the program's mandate.

2.3. Implementation strategies

The program worked at national, district, and health facility levels to support the Government of Uganda to implement strategic activities in the NAP.

2.3.1. National-level activities

National-level activities focused on developing relevant guidelines and policies; strengthening governance through the operationalization of governance structures of the NAP, including technical working com-

Table 1
Guiding principles to build country ownership and self-reliance.

Approach	Description
Use a systems-strengthening approach	All program activities aimed to build capacities across the six components of a pharmaceutical system (i.e., governance, human resources for health, information, financing, medicines and technologies, and service delivery) (Supplementary Fig. 1).
Optimize the allocation and use of resources for medicines and related functions in health systems	The program worked with existing projects to identify synergies and augment infection prevention and control (IPC), water, sanitation, and hygiene (WASH), and antimicrobial stewardship (AMS) activities based on best practices and lessons from the program.
Build on and strengthen existing systems	The program worked with existing Government of Uganda structures at national, subnational, and health facility levels, and supported building capacity to implement program activities.
Support integration	Activities were integrated in existing programs at all levels. At the national level, activities were integrated in the workplans of the various technical working committees (TWCs). At the health facility level, integration was done with existing continuous quality improvement (CQI) initiatives.
Build/strengthen the capacity of local nongovernmental organizations (NGOs)	The program identified and worked collaboratively with national and subnational stakeholders, including civil society organizations (CSOs); NGOs; government ministries, departments, and agencies; academic institutions; and professional associations. The program worked with both the Uganda protestant medical bureau and Uganda catholic medical bureau, CSOs that manage over 300 church-founded health facilities to incorporate AMR in institutional and health facility programing.
Support country-led coordination	All project activities were centrally coordinated by the Government of Uganda to ensure government ownership, institutionalization, and sustainability, and to avoid duplication, while building in-country and local capacity for long-term coordination.

mittees (TWCs) of the National AMR Sub-Committee (NAMRsC); building structures for data sharing; and supporting coordination of One Health activities, including linking civil society organizations (CSOs) and professional associations to the NAMRsC's work. The NAMRsC is the highest-level technical body mandated to facilitate, oversee, and coordinate the operationalization of the NAP. It works with five TWCs to implement its mandate. A One Health MSC approach was used for this work, bringing together key partners and government ministries. The program strengthened human resource capacities for MSC, IPC, and AMS through sensitization, training, curriculum reviews at six medical schools, and collaborating to write a relevant policy brief to guide education of the One Health workforce. Governance for IPC was strengthened using the WHO National Infection Prevention and Control Assessment Tool 2 (IPCAT-2) to review the national IPC program, to make recommendations, and to take corrective actions.

2.3.2. District- and health facility-level activities

The program worked with the Ministry of Health (MOH) to identify 13 health facilities designated for interventions on IPC and AMS (Supplementary Fig. 2). The findings of baseline surveys informed the development of action plans and targets for improvement (Supplementary Fig. 3). The program collaborated with local counterparts to apply continuous quality improvement (CQI) approaches to support health facilities to implement AMS and IPC interventions aimed at improving the quality of services for the containment of AMR (Supplementary Figs. 3–4, Table 1). The CQI plans were informed by global and national best practices in IPC and AMS, including the application of various WHO tools, and the technical tools and checklists developed by the program (Table 2) [20–24]. Annual program work plans aimed to address key elements as shown in Fig. 1. A 17-item facility mentorship tool covering four domains was developed to guide the process of multi-pronged capacity building at the selected intervention health facilities. Among the 13 intervention hospitals, six received intensified support.

The program's capacity building approach for AMS and IPC at selected health facilities consisted of

(i) skills-building workshops, webinars, and sensitization sessions; (ii) "twinning" health facilities with more experienced or better performing health facilities to encourage peer-to-peer learning along with an IPC community of practice; (iii) targeted mentorship by program technical staff in collaboration with the MOH and professional associations. At national level, the program (i) collaborated with academic institutions and professional associations to bridge gaps in both pre-service and in-service training; (ii) generated and shared information at health facility, national, and global levels for action; and (iii) strengthened use of data to inform decision making.

2.4. Monitoring and evaluation

Routine monitoring and evaluation were conducted for all activities at all levels. Regular meetings were held with the health facilities to share data and review progress of activity implementation. At the national level, the program shared progress with stakeholders during quarterly meetings of the NAMRsC and its TWCs. Regular data collection on interventions was done to inform the learning agenda and the review of CQI plans.

2.5. Other GHSA interventions

In February 2021, WHO announced an outbreak of EVD in North Kivu Province, Eastern Democratic Republic of the Congo, near Uganda. The program worked with the MOH and regional partners to implement emergency preparedness activities. Program support focused on strengthening IPC, community engagement based on the health facility ring IPC model, strengthening health protections at border crossings, capacity building for laboratory sample management, and review of the national EVD response plan.

During the COVID-19 pandemic, the program's ongoing interventions enabled it to quickly roll out the IPC mentorship program in five target regions using a high-frequency mentoring model that allowed staff to learn at their facilities without worsening the acute health worker shortages.

3. Results

3.1. One Health multisectoral collaboration

The program directly contributed to 7 of 17 WHO benchmark actions for MSC. The NAMRsC's IPC TWC was established through vetted terms of reference and the appointment of members to the public awareness training and education TWC. The program facilitated the establishment and operationalization of student AMR interest groups, reaching 1,900 students (36.7% female) from medical, pharmacy, nursing, laboratory, and agriculture programs across seven universities The student AMR interest groups achieved eight continuous medical education (CME) sessions, seven journal clubs, three AMR-related grand rounds, and linking clinical mentors to the groups. Last, the program developed a policy brief for the Ministry of Education and Sports and the National Curriculum Development Centre with four recommendations aimed at the inclusion of AMR in the curriculum at various levels of education and training in Uganda. To strengthen data and information sharing, the program built capacity for information and data sharing through the publication and dissemination of biannual One Health AMS newsletters [25]. The program also supported the annual World Antimicrobial Awareness Week activities by organizing

Table 2
The World Health Organization (WHO) tools, methods, and data sources used in the assessment.

Tool	Method of assessment	Data source
Infection Prevention and Control Assessment Framework (IPCAF)	Interviews and observation	Infection prevention and control (IPC) focal person/Nurse in-charges
Hand Hygiene Self-Assessment Framework (HHSAF)	Interviews and observation	IPC focal person/Nurse in-charges/Hand hygiene focal persons
Knowledge and perception survey for health-care workers	Self-administered questionnaire	20 hospital staff per hospital
Hand hygiene compliance assessment tool	Observation	Clinical and ward staff
Antimicrobial stewardship (AMS) practical toolkit for facilities (AMS checklist)	Interviews and observation	AMS focal persons
Point prevalence survey for antibiotic use	Prescription audit	Health facility in-patient prescription records

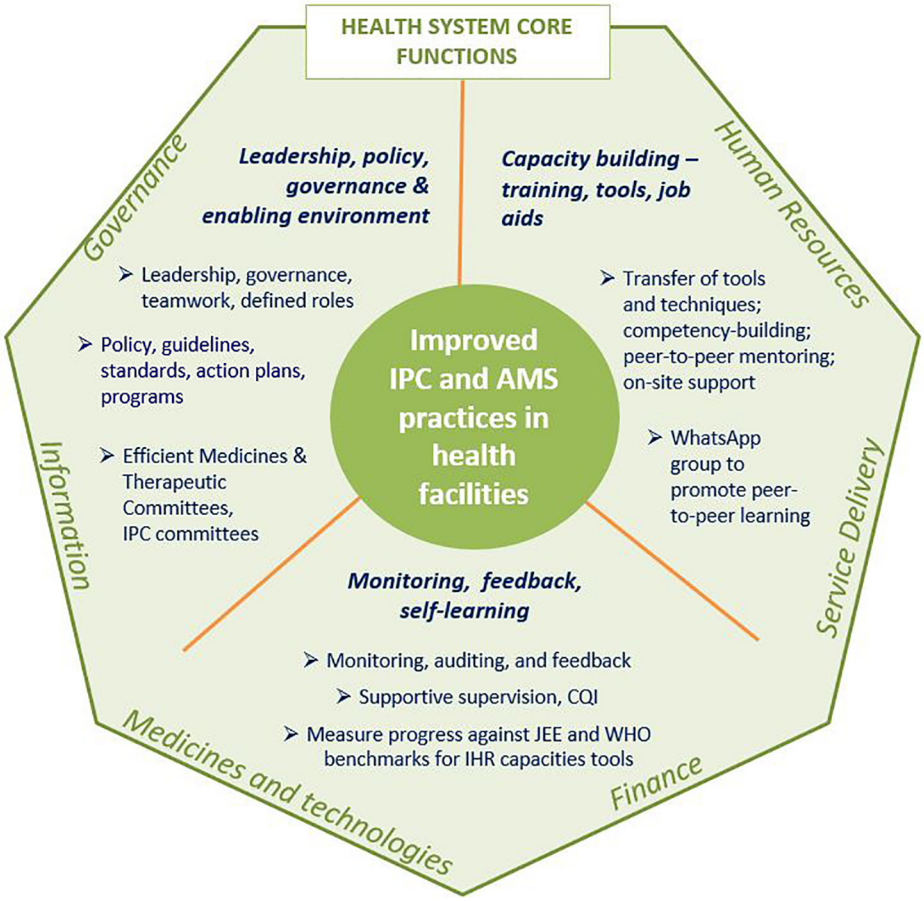

Fig. 1. Key elements of the program's approach to improving IPC and AMS. Abbreviations: CQI, continuous quality improvement; JEE, Joint External Evaluation; WHO, World Health Organization; IHR, International Health Regulations; IPC, infection prevention and control; AMS, antimicrobial stewardship.

webinars and other information exchange activities every year between 2019 and 2022.

3.2. Infection prevention and control

The program supported 16 of 21 WHO benchmark actions for IPC. The MAAIF was supported to develop a national IPC plan for the agricultural sector, and guidelines for IPC and appropriate antibiotic use in the animal sector. They were disseminated to the five leading animal production systems reaching six high production districts across Uganda, 22 district veterinary officers, 23 district production officers, and 127 livestock producers and workers [26].

The program's best practices in IPC and WASH were adopted by five implementing partners. As a result, baseline assessments to inform interventions were conducted by 395 healthcare workers at 277 health facilities and by 364 members of 54 district health teams.

The use of CQI approaches to establish and support the implementation of IPC interventions at health facilities led to observed improvements in IPC capacity (Table 3). All supported health facilities (6/6) improved on the Infection Prevention and Control Assessment Framework (IPCAF), from a baseline median score of 547.0 (interquartile range [IQR] 125.0) in May 2019 to 635.0 (IQR 75.6) in May 2023. At endpoint, six of six hospitals that received intensified support had moved to advanced capacity. Improvement on the Hand Hygiene Self-Assessment Framework (HHSAF) was also observed, with four of six hospitals moving to advanced capacity in the same time frame. One hospital had an increase in HHSAF scores but remained at intermediate capacity and one hospital moved from basic to intermediate capacity. There was observed improvement in hand hygiene (HH) knowledge at all hospitals. The mean score in HH knowledge at baseline was 45.0 % (standard deviation [SD] 9.8 %) in May 2019, increasing to 76.0 % (SD 8.2 %) by May 2023, showing a 69.0 % change in improvement.

3.3. Antimicrobial stewardship

The program supported 9 of 24 WHO benchmark actions for AMS, which includes a key assessment of policies and regulatory frameworks for antimicrobials. An assessment of existing systems for monitoring antimicrobial use and consumption in Uganda resulted in actionable recommendations provided to the government and the National Drug Authority which has been prioritized for the next 5 years. The program supported the National Drug Authority and MAAIF to develop the *Uganda Essential Veterinary Medicines List 2020*, which had not been updated for twenty years [27]. This list was based on principles of evidence-based treatment recommendations, comparative cost-effectiveness, current MAAIF policies, and international recommendations to guide the use of antimicrobials, vaccines, and other essential veterinary medicines.

Ninety-six mentorship visits to hospitals were conducted and additional capacity building activities were implemented, including nine dedicated training sessions for prescribers, 18 CMEs, and two grand rounds, cumulatively reaching 2,244 health workers (54.0 % female) (Fig. 2). The program collaborated with the Pharmaceutical Society of Uganda to conduct two continuing professional development sessions, reaching 109 registered pharmacists in two annual training sessions.

Information and data use were supported through building capacity for hospitals to conduct regular antimicrobial use surveys, using the findings for action and sharing the findings at national and global

Table 3
Baseline and end-line scores for IPCAF, HHSAF, and HH knowledge at six supported health facilities.

Hospital	IPCAF scores (/ 800)		HHSAF scores (/ 500)		HH knowledge (%)	
	Baseline (May 2019)	Repeat (May 2023)	Baseline (May 2019)	Repeat (May 2023)	Baseline (May 2019)	Repeat (May 2023)
Gulu RRH	602	642.5	265	350.0	45.0	83.0
Kumi	395	602.5	312.5	370.0	32.5	74.0
Lacor	590	695.5	217.5	410.5	62.5	84.0
Naggalama	552.5	700.0	217.5	435.0	42.5	63.0
Kiwoko	342.5	655.0	252.5	435.0	41.2	81.0
Kagando	497.5	605.5	162.5	345.0	46.2	71.0
Median (IQR) or mean (SD)	547.0 (125.0)	635.0 (75.6)	252.5 (41.2)	350.0 (81.2)	45.0 (9.8)	76.0 (8.2)

Basic score: IPCAF (201–400), HHSAF (126–250).
Intermediate score: IPCAF (401–600), HHSAF (251–375).
Advanced score: IPCAF (601–800), HHSAF (376–500).

*$P < 0.05$. Abbreviations: RRH, regional referral hospital; IPCAF, Infection Prevention and Control Assessment Framework; HHSAF, Hand Hygiene Self-Assessment Framework; HH, hand hygiene; IQR, interquartile range, SD, standard deviation.

levels to advance the AMR learning agenda. A guide was developed on antimicrobial use surveillance for application at the hospital level, and a framework and software were developed for the National Drug Authority for use for antimicrobial consumption surveillance at the national level. Subsequently, the program supported the national antimicrobial consumption surveillance covering One Health data from 2019 to 2022.

There was observed improvement in antibiotic use for key indications at all supported health facilities. The proportion of patients who were given more than a single antibiotic for the treatment of urinary tract infections decreased from 52.0 % to 27.0 % between June 2019 and July 2022, and the number of antimicrobials per patient treated was reduced by almost 20.0 % [28].

3.4. Outbreak preparedness and response

The program supported the strengthening of governance and institutional human resource capacity during disease outbreaks (Table 4). The national EVD preparedness and action plan was revised. A national EVD vaccine pharmacovigilance pocket guide for health workers was drafted in preparation for potential new EVD vaccine introduction.

4. Discussion

Although several studies have been published on the analysis of a country's progress toward broader IHR capacities, including AMR [29], or focused on AMR surveillance capacity [30,31], to our knowledge, no study has focused on the practical approaches to implementing interventions that are aligned with the WHO benchmark actions for AMR. The program directly impacted 32 WHO benchmark actions (7 for MSC, 16 for IPC, and 9 for AMS), contributing to Uganda's strengthened GHSA capacity through a One Health approach. Completing the WHO benchmark actions is critical to the advancement of Uganda's capacity levels on the JEE. For example, before the program was launched in January 2019, Uganda had not applied the

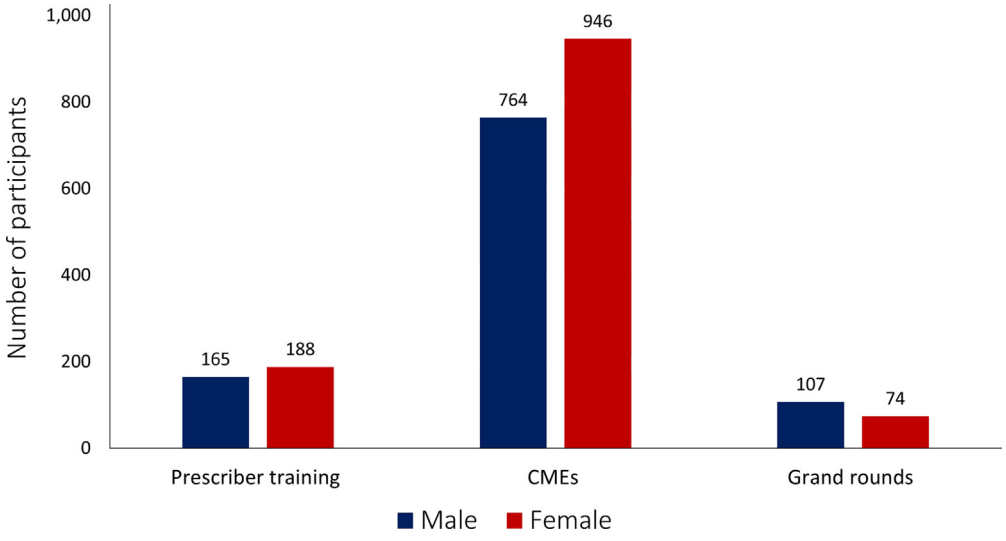

Fig. 2. Number of health workers reached through capacity building activities for antimicrobial stewardship. Abbreviation: CME, continuous medical education.

Table 4
Key health security interventions during disease outbreaks.

EVD outbreak	COVID-19 emergency response
745 health workers were trained in IPC for EVD, including sample collection and transportation. Conducted simulation exercises for 8 district IPC teams, targeting 56 health workers for EVD preparedness.	Worked with the MOH to coordinate IPC for the COVID-19 response in 5 health regions, 45 districts, and 858 health facilities. Supported the establishment of 45 district IPC teams, composed of 231 males and 255 females. Trained 486 IPC mentors linked to 858 health facilities for COVID-19. Trained 5,452 health workers in IPC for COVID-19. 5,148 mentorship visits conducted for COVID-19.

Abbreviations: IPC, infection prevention and control; EVD, Ebola virus disease; MOH, Ministry of Health; COVID-19, coronavirus disease 2019.

IPCAF and IPCAT-2 assessment tools at health facility and national levels. There were no national IPC guidelines, policy, or plans for animal health. Monitoring of IPC practices using the HHSAF, HH compliance observation tools, and WASH facility improvement tool—which was previously not applied in the human health sector—is now routine practice as a result of the program's interventions [16]. The national IPC plan for the animal health sector will accelerate the implementation of the NAP and bridge the gap between the animal health and human health sectors. This strengthens Uganda's One Health effort for the prevention of zoonotic diseases and reduces the unnecessary use of antibiotics in food production, mitigating the emergence of drug-resistant infections [32].

The program's work to improve IPC and AMS practices at health facilities contributes to better service delivery and AMR control efforts [33]. Moreover, cascading this work to other health facilities through technical assistance contributed to the pathway to sustainability of interventions because 364 members from 54 district health teams and 395 healthcare workers at 277 health facilities spread across the country acquired the knowledge and skills to design and implement IPC interventions. Training health workers on IPC created a pool of experts who eventually supported the national COVID-19 and EVD response efforts. Capacity built before an outbreak is critical to epidemic response and other GHSA action packages, specifically medical countermeasures and personnel deployment can benefit from this work [34].

Assessment findings on stewardship policies, activities, regulatory framework, and supply chain management of antimicrobials spurred the government to develop a national AMS action plan with priority interventions. Data and information sharing are critical to AMR containment. The creation of standard operating procedures and systems for antimicrobial use surveillance at intervention health facilities helped the country maintain a key capacity level 3 activity relating to WHO benchmark 3.4 on AMS. Surveillance and data use were critical for driving action for AMS programs at the facility level and are a scalable intervention at the national level.

Using CQI approaches, the demonstrated reduction in unnecessary antibiotic use at the health facilities supported by the program [28,35] will contribute to slowing the emergence and spread of AMR. To foster the spirit of learning, the program shared challenges identified in setting up systems for antibiotic use surveillance and made recommendations to improve antibiotic use surveillance in a resource-limited setting [36,37]. Inadequate knowledge about AMR and AMS has been widely documented among health workers in resource-limited settings. The WHO developed guidance to help address this challenge. Similarly, human resource challenges hinder successful outbreak response. Through targeted training, CME, continuing professional development, mentorships, and working with professional bodies, the program demonstrated a feasible approach to sustainable AMS capacity building that can be replicated in similar settings. Using success built on the AMR platform, the program provided additional support to other disease outbreaks, including COVID-19 and EVD. The human resource structures built for AMR were efficiently used to cascade interventions, and the health facilities were deployed to support district teams and lower-level health facilities during the outbreaks.

One limitation to program implementation was the lack of surveillance capacity at the supported health facilities. Although Uganda has built capacity for AMR surveillance, with the country submitting data to the WHO Global Antimicrobial Resistance and Use Surveillance System, many health facilities still lack the necessary capacity (clinical, epidemiological and laboratory) for AMR surveillance. Efforts towards mandating AMR surveillance at additional health facilities in Uganda should be enhanced at both human and animal health surveillance sites [38].

4.1. Lessons learned

Engaging CSOs, professional bodies, and the private sector provides momentum and accelerates activity implementation. Through our work with the medical bureaus, we were able to add key health facilities, engage more professional membership in the AMR response, and advocate for wider societal involvement in AMR activities. This wider stakeholder engagement, contributing to the whole-of-society approach, was critical to the success of our work and to overcoming bottlenecks. For example, medical bureaus and the professional associations provided leadership for their health facilities and members respectively to support program activities. Sustainable capacity building requires a multipronged approach with specific involvement of the professional bodies in integrating AMR containment training in in-service and pre-service training.

Routine assessments are essential for identifying IPC and AMS gaps. It is important to use the data generated to inform interventions and build interest among healthcare workers. Moreover, the data can help prioritize interventions, with an emphasis on starting with "low-hanging fruits" or quick wins. CQI approaches are feasible and scalable to systematically strengthen IPC and reduce antibiotic use at the facility level, thereby improving patient and health worker safety. Public awareness, training, and education should be implemented in unison with other NAP strategic objectives. Although most interventions currently focus on IPC and AMS at health facilities, the successful implementation of these activities requires a wider engagement of the public to increase compliance not only with practices at the health facilities but also behaviours in the community that promote responsible antibiotic use and hygiene practices for infection prevention.

4.2. Challenges and recommendations

Despite improvement in MSC, the current governance structures for the One Health technical working group are not established by policy. Therefore, governance, decision making, financing, and activity implementation challenges remain, with the platform mainly funded and supported by implementing partners to perform its functions.

Given the estimated budget of US $206.5 million over a five-year period for the NAP, low financing for AMR remains a barrier to the completion of key WHO IHR capacities benchmark actions and the advancement of the JEE capacities. Key benchmark actions beyond capacity 4 require countrywide reach and financial commitments, which are not currently met, thereby limiting the reach and impact of interventions. Addressing this will require greater government commitment and increased public financing and investments for health security.

Human resource gaps remain a challenge in the advancement of the AMR agenda at both national and subnational levels. There is a need for further financial investments to build the country's human resource

capacity for global health security / AMR implementation. Public awareness, training, and education should be implemented in unison with other NAP strategic objectives. The successful implementation of the NAP depends on proper awareness of the burden of AMR across all sectors of society. This includes exploring how best to effectively engage various private sector providers including the animal and fisheries industry and the pharmaceutical industry.

In conclusion, the program supported systematic capacity strengthening based on the JEE's capacity advancement framework for global health security, specifically relating to AMR. We demonstrated progress made according to WHO benchmark actions. Further support is needed for the country to address policy bottlenecks for One Health, increase financing for AMR, and advance the country's JEE capacity to level 5.

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Conflict of interest statement

The authors declare that there are no conflicts of interest.

Author contributions

Reuben Kiggundu: Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. **J.P. Waswa:** Formal analysis, Investigation, Methodology, Visualization, Writing – review & editing. **Niranjan Konduri:** Conceptualization, Methodology, Supervision, Writing – review & editing. **Hassan Kasujja:** Formal analysis, Investigation, Methodology. **Marion Murungi:** Formal analysis, Investigation, Methodology. **Patrick Vudriko:** Investigation, Methodology. **Harriet Akello:** Supervision, Methodology, Validation. **Eric Lugada:** Resources, Project Administration, Supervision. **Cecilia Muiva:** Methodology, Project administration. **Esther Were:** Project administration. **Dinah Tjipura:** Project administration. **Henry Kajumbula:** Supervision, Methodology, Validation. **Kate Kikule:** Methodology. **Emmanuel Nfor:** Resources, Supervision, Writing – review & editing. **Mohan P. Joshi:** Methodology, Supervision, Writing – review & editing.

Supplementary data

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