Antimicrobial resistance and stewardship among stakeholders of the poultry value chain in Wakiso and Soroti districts, Uganda

Knowledge, attitudes and practices report

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October 2023

ILRI thanks all donors and organizations which globally support its work through their contributions to the CGIAR Trust Fund

Editing, design and layout—ILRI Editorial and Publishing Services, Addis Ababa, Ethiopia.

Photo credit: ILRI/Pamela Wairagala.

ISBN: 92-9146-796-0

Citation: Ssajjakambwe, P., Atuheire, C., Okello, J., Kakooza, S., Waiswa, J., Ayebare, D., Roesel, K. and Moodley, A. 2023. *Antimicrobial resistance and stewardship among stakeholders of the poultry value chain in Wakiso and Soroti districts, Uganda: Knowledge, attitudes and practices report*. Nairobi, Kenya: ILRI.

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Acknowledgements

This report was compiled by Paul Ssajjakambwe of Makerere University's College of Veterinary Medicine, Animal Resources and Biosecurity (COVAB) on behalf of Vétérinaires Sans Frontières Germany (VSF-G) Uganda, the field extension partner of the Boosting Uganda's Investment in Livestock Development (BUILD) project. The BUILD project is a five-year research for development project led by the International Livestock Research Institute (ILRI) and funded by the German government through the Federal Ministry of Economic Cooperation and Development (BMZ). The project involves partners in policy making in Uganda and East Africa, research collaborators in Uganda, Kenya and Germany as well as an extension partner, VSF-G, to help turn research evidence into use.

We express our gratitude to the participants that were consulted during the study that resulted in this report.

Abbreviations and acronyms

AGP	Agricultural Growth Promoter
AMR	Antimicrobial resistance
AMU	Antimicrobial Use
AMUSE	Antimicrobial use in livestock production (tool)
BMZ	German Federal Ministry for Economic Cooperation and Development
BUILD	Boosting Uganda's Investment in Livestock Development
FAO	Food and Agricultural Organization of the United Nations
GAP	Global Action Plan
GDP	Gross domestic product
GPS	Global Positioning System
IDI	Infectious Diseases Institute
ILRI	International Livestock Research Institute
JICA	Japan International Cooperation Agency
KAP	Knowledge, Attitudes and Practices
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MoH	Ministry of Health
NADDEC	National Animal Disease Diagnostics and Epidemiology Centre
NAP	National Action Plan
NDA	National Drug Authority
ODK	Open Data Kit
SDGs	Sustainable Development Goals
UBOS	Uganda Bureau of Statistics
VSF	Vétérinaires Sans Frontìeres
WHO	World Health Organization

Key definitions

Antimicrobial: medicines that destroy or inhibit the growth of microorganisms, especially pathogenic microorganisms including bacteria, viruses, fungi/mold, insects, ticks, helminths and protozoa.

Antimicrobial resistance: this is an occurrence whereby microorganisms e.g. bacteria or fungi develop mechanisms to defeat the killing effects of the medicines designed to kill them.

Drug outlets: facilities (drugs shops and pharmacies) dispensing drugs to farmers/customers at retail rates, exclusive of importers and manufacturers.

Farms: agricultural settings, either commercial or subsistence, with infrastructure and personnel, where poultry are reared for meat and/or egg production.

Markets: sites where food, live birds and products such as meat and eggs are sold at retail or whole ale rates.

Consumer points: roadside food vendors, restaurants or guest houses (also could be referred to a ready to eat places).

Policy regulators: MAAIF and NDA staff.

Prophylaxis: administration of an antimicrobial to prevent occurrence of a specific disease outcome.

Metaphylaxis: administration of an antimicrobial to prevent the spread of an illness identified in one animal as livestock share water, shelter, feeds.

Growth promotion: administration of an antimicrobial, exclusively to enhance and accelerate growth in animals.

Executive summary

Vétérinaires Sans Frontières (VSF) Germany, through the project Boosting Uganda's Investments in Livestock Development (BUILD), contracted Paul Ssajjakambwe of Makerere University's College of Veterinary Medicine, Animal Resources and Biosecurity (COVAB) to design a capacity building strategy aimed at reducing antimicrobial resistance (AMR) and enhancing safety and consumer protection in the poultry value chain. The activity was carried out in Soroti and Wakiso districts of Uganda using the Antimicrobial Use (AMUSE) tool (Wieland et al. 2019).

This study provided insights into the current levels of knowledge, attitudes and practices (KAP) among poultry value chain stakeholders in the two selected study districts, Wakiso and Soroti. It also provided a guide for improving capacity building and public relation activities designed to impact how people perceive safety, AMR and AMU. The data and information captured will serve as benchmarks for monitoring and evaluating the project intervention activities. This will include identifying areas in need of further attention and developing approaches to capitalize on the behaviours and practices that support application of the AMUSE approach.

In a KAPs survey on antimicrobial stewardship conducted in Wakiso and Soroti using a value chain approach, 73% of the participants reported that they had inadequate knowledge on AMR, $p=0.001$. Approximately 92% of the participants showed a positive attitude towards urgent provision of training in antimicrobial stewardship, $p<0.001$. In addition, they expressed the need to be trained by qualified veterinarians, 93%, $p<0.0001$. Furthermore, 8% of the farmers use Agricultural Growth Promoters (AGPs) daily, more so than those from Soroti (10%). The use of antibiotics for prophylaxis among poultry farmers was 81% in Soroti and 46% in Wakiso. Approximately 25% of the farmers did not observe withdraw period regulations.

From the above snapshot, there is need to raise awareness on appropriate antimicrobial stewardship to prevent and/or control AMR in the poultry value chain. This is a key deliverable of the BUILD project, which is in line with Uganda's AMR National Action Plan (NAP). A multi-sectoral approach targeting veterinary professionals, farmers and other stakeholders would be best, with independent evaluation at selected time points to assess change and impact. This will strengthen the efforts of the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) and its partners in preventing or controlling poor antimicrobial stewardship and increased AMR in the poultry value chain.

1. Introduction

1.1 Vétérinaires Sans Frontières Germany (VSFG)

Vétérinaires Sans Frontières Germany (VSFG) is a non-profit organization that has been working in the Greater Horn of Africa region since 1998. It is headquartered in Berlin, Germany, with a regional office in Nairobi, Kenya as well as country and field offices in Ethiopia, Kenya, Somalia, South Sudan, Sudan and Uganda. VSFG is part of VSF International, which operates in more than 40 low- and middle-income countries (http://vsf-international.org/).

1.2 The BUILD project

Boosting Uganda's Investment in Livestock Development (BUILD) is a five-year research-for-development project funded by the German government through the Federal Ministry of Economic Cooperation and Development (BMZ). It is implemented by the International Livestock Research Institute (ILRI) in partnership with Uganda's Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), the National Livestock Resources Research Institute (NaLIRRI), VSFG, the German Federal Research Institute for Animal Health (FLI), the German Federal Institute for Risk Assessment (BfR), and Freie University of Berlin.

BUILD activities are mainly carried out in Uganda and to a smaller extent in Kenya, with regional engagement in other countries i. The project focuses on the following technical areas, based on relevance under the MAAIF: 1) the control of Peste des petits ruminants (PPR), 2) the control of Rift Valley fever (RVF), 3) the control of antimicrobial resistance (AMR), and 4) improved meat safety, occupational health and disease surveillance at the point of slaughter.

1.3 The poultry industry in Uganda

Uganda has one of the world's most rapidly growing populations, with a corresponding rise in the demand for food. Poultry, which requires a relatively short time and small space to raise compared to other livestock, is a common source of protein in the form of eggs and meat in many parts of the country. As a result, poultry rearing is a fast-growing enterprise, especially in peri-urban areas (UBOS 2012). Chickens dominate the Ugandan poultry industry, and the national poultry population is estimated to be 46 million (UBOS 2018), of which 88% is indigenous and free range. Surprisingly, egg production for major markets is dependent on the 12% under intensive systems such as battery cage.

The nutritional value of chicken eggs and meat cannot be overstated, especially among vulnerable groups such as children and expectant and nursing mothers (Food and Agriculture Organization of the United Nations; FAO report[1]). However, the rampant use of unprescribed antimicrobials on poultry farms could negate these benefits.

1 http://www.fao.org/antimicrobial-resistance/background/what-is-it/en/

The administering of these drugs without professional veterinary guidance has led to antimicrobial resistance and the presence of drug residue in foods of animal origin, posing a danger to animal and human health (Bashahun and Odoch 2015).

1.4 AMR and antimicrobial stewardship in Uganda

The use of antimicrobials for disease prophylaxis, metaphylaxis and treatment dates back to 350–550AD (reviewed by Aminov 2010). Some of the antimicrobials used in poultry husbandry are penicillin, tetracyclines, sulfonamides, tylosin, monensin, fluroquinolones, lincosamides, amprolium, toltrazuril, ivermectin and benzimidazoles (Mathew et al. 2007; Gyles 2008). In 2010, some 63,151 tons of antimicrobials were used on food animals globally and this is expected to rise by an estimated 67% by 2030 (Barbhuiya et al. 2019).

AMR is a public and animal health threat that occurs when antimicrobials are rendered ineffective as microbes develop mechanisms to reverse the effects of the drugs (Tenover, 2006). This global problem causes devastating losses, especially in developing countries, and constrains the Sustainable Development Goals (SDGs) concerning poverty, hunger, health and economic growth. In 2019 alone, an estimated 4·95 million deaths were associated with bacterial AMR, including 1.27 million deaths attributable to bacterial AMR. At the regional level, the all-age death rate attributable to resistance was highest in sub-Saharan Africa (Lancet, 2022). It is predicted that the world is heading to a period where previously manageable infections and injuries will lead to even more loss of life (Ampaire et al. 2016; Barbhuiya et al. 2019), an estimated 10 million human deaths annually by 2050 (Clifford et al. 2018). Globally, USD 4-5 billion is spent on managing illnesses caused by resistant bacteria every year (Kilonzo-Nthenge et al. 2008). Furthermore, AMR currently leads to a 0.4-1.6% reduction in global Gross Domestic Product (GDP) due to an increase in cost of production and loss of animals and this is expected to increase to 3.5%, amounting to USD 100 trillion in global GDP, by 2050 (Barbhuiya et al. 2019).

AMR has been reported since the 1950s (Barhuiya et al. 2019). In 1951, Starr and Reynolds reported streptomycin resistance in coliforms in turkeys that were fed this antimicrobial (Mathew et al. 2007). AMR has been attributed to the continuous and prolonged misuse and overuse of antimicrobials in commercial poultry feeds and drugs (Kimera et al. 2020). It has been precipitated by the increased demand and worldwide acceptability of chicken over beef and pork, which has led to overcrowding of poultry farms in a bid to provide a faster and cheaper source of proteins. To compensate for the unhygienic conditions that could result in infections and to promote faster growth, poultry farmers often resort to giving their birds sub-therapeutic doses of antimicrobial agents (Kumar et al. 2019). The withdraw period recommended by the manufacturers is not observed (Nouws 1990), leading to a likelihood of drug residue in foods of poultry origin. Furthermore, it is estimated that meat production will increase annually from 200 million tons to 470 million tons by 2050 and this is correlated with increased antimicrobial use (Clifford et al. 2018).

The overuse and misuse of antimicrobials is influenced by factors such as an increased disease burden, which forces farmers to administer excessive amounts of drugs in a bid to prevent further loss. Limited access to animal and plant health experts, as well as limitations in the training and support of these experts, results in malpractices such as the use of antimicrobials as growth and production promoters in animals. Furthermore, lack of drug regulation, access to over the counter or internet sales and availability of substandard and counterfeit antimicrobials make drugs readily available even without a prescription. Lack of awareness regarding good practices as well as anthropological, sociocultural, political, and economic factors also pose barriers to good practices regarding antimicrobials.

Surveillance and monitoring are recognized globally as crucial elements in the response to AMR. They are among the five strategies of the Global Action Plan (GAP) of the World Health Organization (WHO) using which countries can collect data on antimicrobial use and resistance to identify the population at risk of AMR, assist in policy prioritization and develop a guide for treatment (Opintan et al. 2018). However, despite these WHO recommendations, AMR

surveillance levels in East African countries are still insufficient (Ampaire et al. 2016). To complicate the problem, there is indiscriminate use of antimicrobials, which leads to selection for the resistant bacteria (Khan 2018).

Antimicrobial misuse and overuse occur at all levels of the drug distribution chain in Uganda, including prescription, trade, administration and handling. This has contributed to the development of AMR, with animals and the environment as potential reservoirs. Extensive use of these drugs is common in intensive livestock systems, where increased demand for animal products and flawed biosecurity practices add up to higher incidences of disease. Ineffectual implementation of policies on antibiotic use in Uganda accelerates the injudicious use of antimicrobials in the poultry value chain. In addition, animal-source foods are sold without respecting withdraw periods, resulting in unacceptable drug residue levels in products such as eggs and meat and hindering international competitiveness. These drug residues are potential threats to human health and continuous exposure renders treatment for bacterial infections ineffective.

Currently, Uganda lacks a national routine program for AMR surveillance in animals. Instead, there is sporadic case by case surveillance and detection on a needs basis or under selected research projects with support from partners in the animal industry. This is combined with the cross mandates between MAAIF for drug use at production level and the Ministry of Health (MoH) at food safety level. That said, there is a need for pragmatic policies to counter the knowledge, attitudes and practices (KAP) that contribute to AMR, including lack of extension services, compounded by misinformation and drug misuse. This survey investigated KAPs with respect to antimicrobial stewardship along the poultry value chain in Wakiso and Soroti districts in Uganda.

1.4.1 General objective

To design a capacity development strategy based on the KAP assessment.

1.4.2 Specific objectives

a. Generate evidence-based data on key stakeholders' KAP to identify possible incentives for antimicrobial use / antimicrobial consumption (AMU/AMC) reduction and targeted stewardship in poultry value chains in selected districts in Soroti and Wakiso districts, Uganda.

b. Provide data to inform a capacity gap analysis to develop evidence-based interventions addressing AMU and AMR among the poultry value chain actors, with emphasis on personnel, infrastructure and legislation.

c. Generate data to inform the strategy for promotion of good antimicrobial stewardship change and AMR control interventions along the poultry value chain.

1.5 Methodology

1.5.1 Study areas and sample size

a) The study areas were sub-districts in Wakiso in the Central Region and Soroti in the Eastern Region of Uganda.

b) Since the districts lacked credible information on the numbers of farmers and drug shops in their locations, a purposive sampling strategy was employed. The target was to visit and map out at least 100 poultry farms and 20 drug shops. Actual descriptive statistics per category are indicated in Table 1.

Table 1: Breakdown of poultry value chain respondents in Wakiso and Soroti districts of Uganda

Stakeholders/ Districts	Wakiso	Soroti	Total
Drug outlets	15	11	26
Farms	110	69	179
Consumers	15	9	24
Markets	2	1	3
Policy regulators	8	9	17

1.5.2 Approach

To develop the inception report, selected documents and publications were reviewed, and primary data collected using a modified AMUSE tool (Wieland et al. 2019) during the field engagements. Thereafter, data sets were analyzed to generate inferential statistics that are shared in the subsequent sections of this report. The key stakeholders targeted were veterinary drug shop/ pharmacy attendants, field veterinarians (public and private), poultry farmers, traders, consumers and the Department of Animal Health at MAAIF.

1.5.3 Methods

a) A stakeholder analysis of key players and influencers of antimicrobial production and use was conducted (using tools from the OH-SMART™ toolkit) to identify actors who could potentially influence the reduction of AMU/AMR at the community level using multi-stakeholder action planning strategies.

b) Questionnaires were administered using open-source software Open Data Kit (ODK) (Brunette & Hartung, 2023) on smart phones to the target groups (veterinary drug shop/pharmacy attendants, field veterinarians, poultry farmers, traders and consumers) regarding antimicrobial stewardship (knowledge, attitudes and practices). The accumulated data was saved and sent to the server for further handling and processing.

c) In-depth interviews were conducted among key informants to identify some of the drivers of AMU amongst poultry producers in Wakiso and Soroti districts.

d) The synthesized data on attitudes and practices gained from (1.6.3a-1.6.3c) will be used to develop / contribute to:

i. A set of appropriate AMU and residue prevention training modules for key stakeholders or future AMR awareness efforts among farmers, animal health practitioners and veterinary drug outlets. These materials will also be used for the continuous professional development of practicing government and private veterinarians. They will cover antimicrobial stewardship and regulations related to responsible drug use and management, judicious drug use, monitoring of antimicrobial residue in meat and eggs, and use of a One Health approach towards AMR prevention.

ii. AMR and AMU training/learning/awareness tools such as case studies, posters, manuals and brochures.

iii. Tools that inform policy e.g. policy briefs on AMR/AMU while adding value to the National Action Plans (NAPs).

1.6 Deliverables

i. Data on KAP within the poultry value chain in Wakiso and Soroti districts.

ii. Gaps identified in i above and suggested interventions.

iii. Map of farmer and drug outlet locations identified using the Global Positioning System (GPS) in Wakiso and Soroti districts.

1.7 Strengths and weaknesses of the selected design and research methods

1.7.1 Strengths

i. The multidisciplinary team derived input from not only animal health service providers but human health service professionals as well. This was against the backdrop of antimicrobial crossover use from humans to animals, especially in the poultry and pig value chains.

ii. Since the data collection (purposive sampling) approach involved stakeholder identification, it facilitated reasonable data collection along the drug use chain from the drug outlet to the consumer point. The drug use practices were quite different yet important in informing this research.

1.7.2 Limitations

i. There was no readily available data on the numbers of drug shops, farmers and farms in the districts of Wakiso and Soroti, thus the sample size determinant was unfeasible. This necessitated using a purposive sampling strategy. Each respondent had to consent before the interractions of data collection.

ii. Key members of the MAAIF and NDA top management were not available for key informant interviews. Therefore, we used the objectives of this assignments as talking points for a guided discussion rather than our tool designed for systematic key informant interviews.

2.Key findings

2.1 Identification of stakeholders in the poultry value chain

Using the One Health Systems Mapping and Analysis Resource Toolkit (OH-SMART), we identified various stakeholders in the poultry value chain key at the following activity points:

2.1.1 Drug outlets

These were facilities that were composed of importers, distributors, pharmacies or drug shops. They are key in the transfer of an antimicrobial from a manufacturer, down the value chain until it reaches the consumers, at the food table who may consume the antimicrobial residues unknowingly.

2.1.2 Farm

Among these, ranged from subsistence to commercial farms. The famers on site, were identified as key users of the antimicrobials on the establishments. Later on, the products (eggs and meat) would be send to the markets for sale.

2.1.3 Markets

In Uganda`s setting, the markets ranged from formal to informal. Some of the sales points are well designated and products from the farms are delivered for sale. However, often times, sales are also made at the roadside, backyard or on farm which may not necessarily reach the well-organized market points.

2.1.4 Consumer points

In this study, they were defined as food eating points such as restaurants, motels, hotels, among others. These are the typical end destination of poultry products for human consumption.

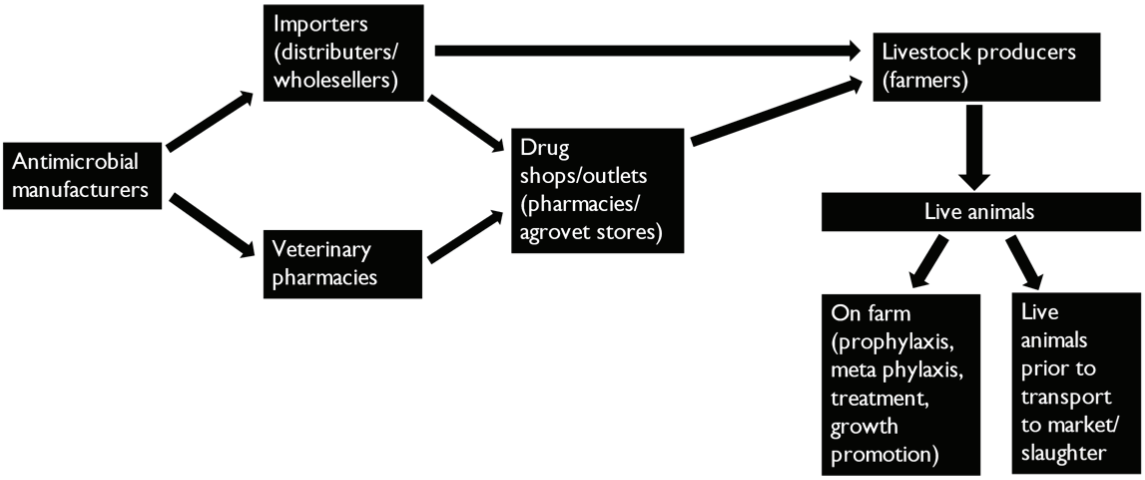
2.1.5 Policy/regulators

This category is mainly composed of agencies such as the National Drug Authority and the Uganda National Bureau of Standards who play a key role in monitoring, regulation and enforcement of the established policies to safeguard the public from access and consuming food products that may have potential threat to the health of humans such as antimicrobials, toxins, bacterial contaminants among others.

2.2 Product flow from importation of antimicrobials to their use by consumers

The antimicrobial value chain in Uganda is described in Figure 1.

Figure 1: Veterinary antimicrobial product flow



The general trend in the product flow of veterinary antimicrobials (as illustrated in Figure 1) is as follows: manufacturers sell the drugs to distributors (importers, wholesalers), who then resell to vet pharmacies and drug shops, who in turn sell to farmers to use on their livestock. However, selected farms, especially those with large flocks of >10,000 birds, can access antimicrobials directly from the distributor at relatively cheaper rates. Furthermore, some distributors such as MTK Uganda Ltd, Norbrook and Eram Uganda Ltd employ veterinarians who offer extension services, including professional advice and prescriptions, to large-scale farms. These employees promote easier and faster uptake of the companies' products. However, most poultry farmers do not have prescriptions when they buy microbials, thus exacerbating misuse and increasing development of AMR. Lastly, when the animal-source products are sold, antimicrobial residues in the meat (a result of not adhering to the withdrawal periods) can end up in markets and at consumer points.

Most pharmaceuticals on the market in Uganda are from European countries, especially Germany, Belgium, The Netherlands, Turkey, etc. Other countries supplying antimicrobials include Kenya, Egypt, Jordan, South Africa South Korea, among others. The only veterinary manufacturer in Uganda is Alfasan, but it has not been in production since 2020.

All pharmaceutical dispensaries (pharmacy for human pharmaceuticals, agrovet stores for animal pharmaceuticals) are licensed by the NDA. These drug outlets are the main source of the antimicrobials used on farms. Thereafter, the poultry farm products (meat and eggs, live birds) are sold at outlets such as markets, shops, roadside restaurants, eating points and hotels. The fact that there is neither observation of the drug withdrawal period nor screening for antimicrobial residues in the poultry products means there is a likelihood of antimicrobial residue of unknown amounts with the potential to contribute to AMR in humans.

It is worth noting that some farmers tend to procure drugs from importers or pharmacies directly. The KAP may differ in this group of drug sellers, but we did not interview any of its members, instead concentrating on the majority who supply farmers through drug shops. In addition, the management practices on farms were mainly intensive in Wakiso and free-range or semi-intensive in Soroti. That said, it is common practice to use higher quantities of antimicrobials in the intensive and semi-intensive systems compared to the free-range system.

2.2 Stakeholders interviewed

2.2.1 Veterinary drug sellers

Twenty-six veterinary drug sellers participated in the study. In both districts, there were more female than male respondents, with 66.67% and 54.55% women in Wakiso and Soroti districts, respectively. Most of the drug sellers who participated were in the 19–25-year age group in both districts. Also, most of the drug selling points in the districts were in urban areas, with 86.67% in Wakiso and 63.64% in Soroti.

2.2.2 Animal health field practitioners

In this study, social demographic data on animal health field practitioners was only captured for Soroti District, using the online tool. From the findings, 89% of them had attained a diploma and the same percentage was in the urban areas of the district. In addition, 44.4% belonged to the 25–34-year age group.

2.2.3 Poultry product sellers

These participants were interviewed from the point of production to the market (including live bird markets). A total of 27 participants were involved under this category, with 63% of them in Wakiso District and the remaining 37% in Soroti District. In Wakiso, all the study participants were in peri-urban areas whereas in Soroti 100% of the study participants were in urban areas of the district. About 50% of the study participants in both districts were female.

2.2.4 Poultry farmers

A total of 179 farms were visited: 69 in Soroti and 110 in Wakiso. Farmers in Wakiso mainly kept exotic (non-indigenous) birds compared to those in Soroti who mainly kept local (indigenous) birds.

2.3 Animal AMR surveillance and monitoring

AMR surveillance, detection, reporting, prevention, control and information sharing strategies need a multi-disciplinary and multi-sectoral, or One Health, approach because they involve veterinarians and farmers as well as indirect stakeholders such as traders, drug stockists and consumers. That said, our approach to investigating the current situation employed a value chain approach, from the drug outlets, farms and food markets to the consumer points.

By law, MAAIF through the Directorate of Animal Resources and specifically the Commissioner for Animal Health is mandated to spearhead activities in the animal health sector[2] . There is a national task force on AMR but it does not conduct activities with the desired frequency due to budget constraints and conflicting priorities. The actual tasks are often carried out during studies investigating AMR, after which the researchers are required to share their findings with the office of the Commissioner for Animal Health. In addition, international development partners such as the Japan International Cooperation Agency (JICA) and the Infectious Diseases Institute (IDI) have provided expertise and equipment for MAAIF's National Animal Disease Diagnostics and Epidemiology Centre (NADDEC) laboratories to aid the improvement of AMR surveillance, detection, reporting and data generation. However, the government and development partners need to do more regarding injudicious antimicrobial use and AMR to reach the required standards for international competitiveness.

2 http://www.agriculture.go.ug/directorate-of-animal-resources/

Among the facilities currently available at the NADDEC labs are conventional bacteriology and selected molecular diagnostics such as identification of antibiograms and resistance markers of selected bacteria. Much as this a positive step, there is need to have all the necessary activities run with the required frequency as required by international bodies such as the World Organization for Animal Health (WOAH, founded as OIE) and WHO. This will enable Uganda to submit up-to-date statuses on AMR activities. Furthermore, the National One Health Platform has ended an active engagement through sharing the status quo on AMR, which also culminated into a publication by Musoke et al. 2020. The focus of above activity, which was attended by animal and human health professionals, was to share ongoing or completed activities, some selected data sets and gaps identified, especially in areas of Antimicrobial stewardship.

2.4 Evidence-based data on key stakeholders' KAP and incentives for antimicrobial use

A value chain approach was used to execute this assignment. The key sites visited were drug outlets, farms, food markets and consumer points. Below are the key findings.

2.4.1 AMR perceptions and beliefs

AMR is generally on the rise in the animal sector, with cases reported in the dairy, pork and poultry value chains. This has been caused by the injudicious use of antimicrobials such as tetracycline and penicillin in dairy animals (Ssajjakambwe et al. 2017) or antibiotics and anti-retrovirals in poultry and pigs (Nakato 2020, Ndoboli 2021). In addition, there are isolates from poultry that are non-responsive to the common antibiotics in the market (Unpublished work).

The general perception among farmers is that the antibiotics available in the market are counterfeit or adulterated by unscrupulous traders, but this has not prevented the misuse of these drugs in poultry and other livestock enterprises. This could be due to combination of drugs which may not be compatible, among each other. Among the common malpractices are under-dosing, using the wrong drugs (misdiagnosis) and using antimicrobials meant for human use on animals. A common belief among poultry farmers is that tetracycline/ampicillin intended for human beings can treat chronic coughs in birds. In addition, it is rare to observe the recommended withdraw periods for the frequently used antimicrobials or screen poultry products for these drugs.

As regards AMR among the veterinary practitioners, this is a scenario whereby the drugs known to have effect on selected bacterial pathogens are observed to no longer have the desired effect. This could be as a result of acquisition of genes that code for resistance, the injudicious use of the antimicrobials, among others. A similar observation is shared among other stakeholders such as drug distributors, sales agents but the level of understanding the mechanisms of its manifestation and drivers is subject to their level of training and exposure as regards the scientific basis of AMR.

2.4.2 Behaviours and practices

Drug manufacturers and distributors rarely share information on appropriate drug use and AMR risk with farmers. The occasional farmer seminars organized by these companies focus on product promotion without going into details of AMR. Therefore, most farmers get information, which is sometimes misleading, from fellow farmers. Misinformation leads to grave technical errors in drug use and chronicity of conditions. On this account, there is need for more

emphasis on strengthening appropriate antimicrobial stewardship while contributing to prevention and control of AMR.

2.4.3 Farms

Farmer KAP towards antimicrobial usage

Most of the farmers sampled for this study were female (Table 2), 23% were holders of Ordinary Level certificates; 74% of this these were from Wakiso district. However, some famers in Soroti (27%) possessed a bachelor's degree. In terms of flock size, there were more farmers with more than 1,000 birds in Wakiso compared to Soroti (22% versus 10%, respectively). About 42% of the farmers in Soroti walk farther than 5km to a drug outlet unlike in Wakiso where this is the case for only a small proportion (8%) of famers. The above socio-demographic discrepancies and flock factors could influence the KAP among farmers in the two study districts.

Farmer practices towards vaccines and antimicrobials

Local chicken were the most kept poultry, contributing to 25% of the overall numbers and in Soroti. Farms in Soroti had more crossbreeds (local and Kuroiler) at 27% compared to Wakiso's 13%. This practice may push the indigenous local chicken away from Soroti with time. In this study, over 90% of the farmers obtained their birds through direct purchase, while a very small proportion obtained their chicken through churches and non-governmental organizations (2% and 1%, respectively). Intensive production was the most widely practiced system, especially in Wakiso (86% versus Soroti's 25%, $p<0.001$) and this has a bearing on treatment options in the two districts.

Over 90% of the farmers used conventional antibiotics on their birds. Oxytetracycline was the most widely used in the two districts but farmers in Wakiso also used Keprocil® to a large extent. Other commonly administered drugs were tetracycline and tylosin. Approximately 33% of famers in Soroti administered antibiotics every week, a practice that could exacerbate AMR. The most commonly reported diseases were fowl typhoid (19%), mycoplasmosis and colibacillosis (8%), fowl cholera (11%) and infectious coryza (6%). On the other hand, the top five viral vaccines purchased were Newcastle, followed by Gumboro, infectious bronchitis and fowl pox.

Important to note is that 44% of the famers had never attended training on antimicrobial use. Among those 56% who had received training, 20% had not attended a session on antimicrobial use in the previous six months, especially those in Wakiso District. Consequently, there were issues such as self-medication (4%) and overuse of antibiotics as (AGPs) (29%) in the study population in both districts. About 8% of the farmers used AGPs daily, especially those from Soroti (10%). In addition, 81% of poultry farmers in Soroti used antibiotics as prophylaxis compared to Wakiso, $p<0.001$. Approximately 25% of the farmers did not observe drug withdrawal periods; 46% kept selling their eggs and 52% kept selling their meat after administering antimicrobials in Wakiso. More than 80% of the farmers admitted that they stopped giving medication as soon as a sick bird improved and cared less about completion of the course. About 22% of farmers in Soroti and 13% of Wakiso used human drugs as an alternative to livestock medication, which is contrary to proper antimicrobial stewardship.

Knowledge areas

In this antimicrobial stewardship study, 73% of the participants admitted that they had poor knowledge of AMR ($p=0.001$). Though close, this was more prevalent in Wakiso than Soroti (75% versus 70%). Also, 80%, most of them in Soroti (90%, $p<0.001$), did not know that AMR occurred when a bird's bacterial infections became non-responsive to known antibiotics. However, non-responsiveness to treatment could be as a result of use of a wrong drug. More than half (60%) of the farmers (including the majority in Wakiso, 69%, $p<0.001$), did not know that AMR bacteria could be transmitted from bird to bird. About 56% of the total number of farmers (and 56%, $p=0.01$) in Wakiso) did not know that AMR was a threat in Uganda. It was interesting to note that the majority (77%) of the farmers, more so in Soroti (83%, $P<0.001$), had no idea that resistant bacteria could be found in/on meat or eggs; they believed

these bacteria were only found in the environment. Most of the farmers in Soroti (65%) shared the perception that vaccinations had the potential to reduce AMU, $p<0.001$, while the majority in Soroti (70%) believed AMR could not lead to treatment failure as long as they used strong antibiotics, $p<0.001$.

Attitude areas

Approximately 92% of the participants showed a positive attitude towards urgently receiving training in antimicrobial stewardship, $p<0.001$, and 93%, $p<0.0001$, expressed the need to be trained by qualified veterinarians. A higher number of farmers (58%) in Wakiso strongly believed that AMR in chicken could not affect consumers, compared to 27% in Wakiso, $p<0.001$. Approximately 65% of farmers in Wakiso felt that the Government of Uganda was to blame for AMR. Additionally, 65% of the farmers in Wakiso doubted that good biosecurity measures, proper hygiene practices and vaccinations could tame AMR incidence, $p<0.001$.

Gap analysis in incentives towards antimicrobial usage

Over 70% of the participants complained that they did not receive incentives to put their products on hold during the withdrawal period (especially in Wakiso, 76%) and this deterred them from following many of the recommended practices, $p<0.001$. About 68% of the farmers, most of them in Wakiso (80%, $p<0.001$) confessed that they had never obtained information on proper antimicrobial use from the veterinary district veterinary office.

2.5 Veterinary drug outlets

A total of 26 poultry drug sellers were studied, 11 in Soroti and 15 in Wakiso. About 38% were female (5 from Soroti and 5 from Wakiso) and 61% were male (6 from Soroti and 10 from Wakiso). Most drug sellers were between 19–25 years old. Of the enterprises studied, 81% were drug shops and the rest veterinary pharmacies.

2.5.1 Practices towards antimicrobial resistance among veterinary (poultry) drug sellers

Approximately 11% of the drug sellers had no previous training on poultry antibiotic dispensing, while 58% had not attended any training on AMR, including the majority from Wakiso (68%). Exactly 50% of the sellers had 1–5 years' experience in veterinary drug sales. Farmers constitute 96% of the customers of these veterinary drug shops. The antibiotics most purchased by farmers are tetracycline, oxytetracyline, aliseryl and sulfadimidine, whereas Newcastle and Gumboro are the most used anti-viral vaccines. Fowl typhoid is the most purchased bacterial vaccine. Approximately 46% of the drug sellers preferred selling oral antibiotics to parenteral ones.

Only 38% of drug sellers used laboratory results to guide their prescription while 69% of the time, less than 2 farmers approached the drug shops with laboratory results. This was even worse in Soroti. Thus, there is an urgent need for diagnostic animal laboratories and services in the two study areas. In addition, drug sellers often take long, if they ever do, to train farmers on the proper use of antibiotics.

2.5.2 Knowledge on antimicrobial resistance among veterinary (poultry) drug sellers

There was misinformation regarding the occurrence of AMR as 85% of drug sellers thought it occurs when a bird becomes resistant to the antimicrobials administered, $p<0.001$, instead of the microorganism becoming resistant;

this situation was worse among those in Wakiso. It was interesting to note that most drug sellers in Soroti (55%) had poor knowledge on the injudicious use of antibiotics, believing that it only affects birds but not the consumers. Additionally, close to 62% of drug sellers believed that AMR did not contribute to treatment failure if one used strong antibiotics. Approximately 77% of the drug sellers did not know that AMR affected chicken in both poor and rich countries. Further, 55% of drug sellers in Soroti did not know that resistant bacteria could live both in the host and the environment. Though not statistically significant, 58% of the drug sellers thought vaccinations could reduce occurrence of AMR or multi-drug resistant (MDR) infections, a worrying technical blunder in persons entrusted with various antimicrobials.

2.5.3 Attitude towards antimicrobial resistance among veterinary (poultry) drug sellers

Drug sellers, especially in Wakiso District (81%, $p<0.001$), believed that AMR is a result of other factors but not poor prescriptions. A similar percentage in both districts believed that the government of Uganda was responsible for AMR incidence, $p<0.001$. Most drug sellers in Soroti (91%) believed that good biosecurity, hygiene and vaccinations could not contain AMR infections in poultry, $p<0.001$. About 73% of drug sellers in the same district said AMR had boosted their sales, $p<0.001$. However, this is detrimental to the farmers because it contributes to continued losses on the farms.

2.5.4 Gaps existing in antimicrobial usage among veterinary (poultry) drug sellers

In Wakiso, 73% of drug sellers complained that they received no regular training on antimicrobial usage from district officers, $p<0.001$. Overall, drug sellers confessed that farmers who consulted them had no knowledge of antimicrobial use, particularly in Wakiso, $p<0.001$.

2.6 Gap analysis on AMR surveillance, detection and control capacity needs

2.6.1 National surveillance

Routine AMR surveillance enables a country to have credible and reliable data sets for better prevention and control strategies. However, this is not possible in Uganda despite policies being in place, due to resource constraints, especially in terms of consumables and field requirements. The government and partners need to provide finances to support recruitment of additional staff and creation of fully-fledged teams covering different parts of the country through satellite labs/facilities. In addition, facilities like the Wakiso, Kiboga and Mbarara veterinary labs set up by the JICA team lack crucial consumables such as media and antibiotic discs necessary for routine AMR surveillance.

2.6.2 Detection

As mentioned above, AMR surveillance is hindered by a deficiency of supplies that are critical for a facility to carry out dependable and timely detection using conventional and molecular diagnostic technologies. In Uganda, these tests

are often run at the COVAB and NADDEC labs on case-by-case basis for clinicians, farmers or researchers. However, national programs supposed to run on a recommended routine are crippled by fund deficiencies and insufficient data sets as a measure of the extent of a challenge.

2.6.3 Control

A One Health approach is suggested during surveillance and or diagnostics of AMR related challenges. Resource sharing could greatly help reduce of the deficiencies at each facility. Control of AMR in the poultry value chain is inadequate because confirmatory diagnostics are deficient and mainly left to the COVAB and NADDEC labs. Not all farmers are able to access these facilities and the scarcity of extension services across the country compound the problem of insufficient advisory and control services. Possible solutions to this urgent health threat include increasing funding to support AMR diagnostics at regional laboratories as the country works on having services brought closer to the farmers and other stakeholders such as extension and advisory service providers.

2.7 Proposed strategies for promotion of good antimicrobial stewardship and AMR control interventions to the NAP and other stakeholders

Promotion of good antimicrobial stewardship and AMR control interventions will need a multi-disciplinary, multi-sectoral approach. A value chain approach is proposed, from the drug outlets to farms, marketplaces and consumer points. The methods suggested below can best be employed at all value chain levels.

2.7.1 Raising Awareness

Awareness campaigns have been shown to empower stakeholders in an area of concern. A case in point is the push that destigmatized HIV/AIDS in Uganda. Massive campaigns organized by the Ministry of Health and targeting specific interest groups such as fishermen, truck drivers and university students provided the public with proper information on the virus, including demystifying myths on its spread. The same was done during the COVID-19 pandemic in 2020 and the Ebola outbreak in 2022. Other examples are the vaccination campaigns against killer childhood diseases, including polio, whooping cough, measles, tuberculosis, diphtheria and tetanus.

If we are to contribute to fundamental change on antimicrobial use and AMR, empowering the stakeholders with information on the existence of this threat and associated risks would be a good starting point. The methods that could facilitate faster and more effective information uptake are workshops, radio talk shows, televised programs (especially in urban settings) and print media (newspapers, brochures and posters). Understanding the social demographics with respect to language, age groups and media consumption habits provides guidance on the best methods to use. Urban and rural scenarios are different and information penetration varies based on the method and approach used. Also, the method and packaging plus the local dialect will vary between geographical regions and technical or non-technical aspects of the intended messages.

2.7.2 Accountability among professionals and farmers/ traders

Liberalization of veterinary pharmaceutical sales resulted in loss of accountability in terms of who handles various drugs, whether they are authorized or not, the species on which the said drug is used and the administration route. It also contributed to the injudicious use of antimicrobials and escalation of AMR. A solution to this would be centralized regulation and controlled sale of antimicrobials on prescription basis only.

Reports of misuse should be reported to an authorized veterinarian who works with law enforcement officers to bring culprits to book, however, this is still lacking. Knowledge of the implications of agrochemical misuse could also serve as a deterrent. For example, the indiscriminate use of acaricide concoctions mixed with agrochemicals in some districts in the cattle corridor of Uganda led to the misdiagnosis of pneumonia and chronic coughs as contagious bovine pleuropneumonia. Yet, the continued effects of inhalation of the agrochemical substances contribute to progressive lung damage leading to coughs and later, pneumonias diagnosed by Veterinarians after a proper diagnosis. The resultant poisoning proved fatal for some animals on farms especially in the cattle corridor.

Lastly, veterinarians and para-veterinarians, who are custodians of antimicrobials, should be answerable to the regulatory authorities on the use of various drugs in their areas of jurisdiction. This should be supported by written evidence of the source of the drugs, especially those in the controlled or prescription category. This will call for an obvious review of policy since the current codes are weak and worse still rarely effected.

2.7.3 Incentives

The use of incentives has been employed in the Ugandan dairy industry by Jesa Farm Limited, which lowered milk adulteration rates by rewarding milk suppliers who consistently passed screening tests (REF). Incentives in the form of cash and gifts such as milking cans and high-grade breeding bulls has resulted in a noticeable increase in the quality of milk supplied to Jesa farm limited.

This approach can be employed in the poultry value chain by offering higher prices for meat and eggs that pass the antimicrobial residue test. It could encourage farmers to use antimicrobials as required and supply poultry products that are safe for human consumption. Another proposal could be donating day-old chicks or supplies to farmer groups that exhibit best practices with respect to antimicrobial use.

2.8 Proposals for indicators to measure the impact of AMR control interventions

The following are the indicators can be used to measure the impact of AMR control interventions among different mapped sites and among various stakeholders.

2.8.1 Change in practices

A tool to assess AMR status can be applied prior to the awareness campaigns (pre-intervention assessment) and during follow-ups at selected time points (post-intervention assessment), with comparisons drawn to measure the effectiveness of the interventions. This would give meaningful information once carried out over a period of time. This would involve recruitment of respondents and using workshops, radio talk shows, print media etc. to raise awareness about antimicrobials stewardship and AMR risks. It should be done independent of the team implementing the project to reduce bias and prevent conflict of interest.

2.8.2 Evidence-based data on AMR prevalence before and after interventions

This can be actualized by employing an independent investigative team of researchers to carry out surveillance, detection and data reporting prior to, during and after the selected interventions, while working with AMR priority bacteria. This is best done after selecting indicator farms/farmers. As in the previous strategy, the implementers of this activity should be independent to prevent bias and conflict of interest.

2.8.3 Evidence-based collaborative activities – National One Health data sharing platform

Collaboration between departments and sections of MAAIF, especially with respect to data/information on AMR surveillance and detection, should be the norm for better management of health-related threats. Active data sharing using the National One Health Platform should be a key output once the various data sets are uploaded.

2.9 Conclusion and way forward

From the findings of this survey, unacceptable standards of antimicrobial stewardship are prevalent in Wakiso and Soroti districts of Uganda, resulting in health risks not only in the poultry industry but also among humans. According to Clifford et al. (2018), a multidisciplinary, multisectoral approach is best suited to achieving knowledge, attitude and practice changes that will contribute to effective prevention and control of AMR. This calls for partnership between MAAIF, MoH, AMR specialists/consultants and poultry health practitioners. Alongside this, the government, international organizations, drug suppliers, farmers and consumers must make changes within their respective roles to ensure appropriate use of quality veterinary medicine to tackle AMR and secure good health for all.

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