Australasian Review of African Studies, 2021, 42(1), 4-22
http://afsaap.org.au/ARAS/2021-volume-42/
https://doi.org/10.22160/22035184/ARAS-2021-42-1/4-22

AFSAAP 2021

Promoting and monitoring antimicrobial stewardship using veterinary vocational schools in the Democratic Republic of Congo

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Abstract

We conducted a feasibility study of antibiotic stewardship promotion, monitoring and education through veterinary vocational schools using semi-structured interviews and Strength, Weakness, Opportunity, and Threats analysis. Seventeen of the 35 veterinary vocational schools of the Kongo Central Province were surveyed. We report four key results. First, all schools were government funded with personnel capable of promoting, monitoring and educating farmers and communities. Second, these schools were well distributed across the country which gives them access to a greater number of farmers. Third, faculty from these schools provided the bulk of veterinary services in their catchment areas. Fourth, vocational schools would benefit from support from universities. This support could focus on transfer of teaching skills and resources sharing.

Keywords: Antimicrobial resistance, Antibiotic resistance, Antibiotic surveillance, Antibiotic community surveillance, Vocational schools, Democratic Republic of Congo.

Introduction

The statistics of mortality related to antimicrobial resistance (AMR) show an increase over time. In the United States 2.8 million cases of antibiotic resistant infections were reported in 2019 of which 35,000 deaths were recorded (CDC, 2019). The World Health Organisation reported in 2020 close to half a million multi-drug resistant cases globally of Tuberculosis (World Health Organisation, 2020). AMR in human and veterinary medicine is an existing and growing threat to public and animal health and food security throughout the world. Increased contact between humans, animals and wildlife contributes to antibiotic resistance (Wall, Mateus, Marshall, & Pfeiffer, 2016). Several initiatives to address the issue are underway. In this global challenge, low-income countries, like the Democratic Republic of Congo (DRC), face a higher burden because of increased exposure to infections, limited access to quality care, poor governance, shortage of technical personnel in the field and limited stewardship (Collignon, Beggs, Walsh, Gandra, & Laxminayan, 2018; Okeke, Lamikanra, & Eldeman, 1999; Rousham, Unicomb, & Islam, 2018). Thus, low-income countries facing resource constraints must create cost-effective and technically workable solutions to address the issue. This paper reports on a feasibility study that analysed an innovative approach for monitoring antibiotic stewardship through the mobilisation of veterinary vocational schools in DRC.

DRC has 520 veterinary vocational schools scattered across the country with the mission of serving as extension services to promote the animal health and production sector (Data provided by DRC Ministry of Primary, Secondary and Vocational Education, Veterinary Education Division, 2019). The Province of Kongo Central is home to 35 of these schools. These schools are managed by principals and employ faculty holding various degrees: veterinary medical doctor - VMD, veterinary technician, animal production and others. Faculty teaching clinical and technical courses must hold a VMD degree or a graduate degree in a relevant field such as animal production. Faculty holding a veterinary technician degree are classified as “under-qualified” by government regulations governing veterinary vocational education. Faculty with a veterinary background (VMD or veterinary technician) are involved in private practice on farms located in the schools’ catchment areas (a walking distance from the school) where they take students for field practicum.

DRC public veterinary services work with limited human and financial resources. Veterinary Technicians provide all veterinary services, to the best of their abilities, in the absence of VMDs in rural and remote areas. They teach clinical and technical courses at veterinary vocational schools – a role reserved for VMDs and faculty holding a graduate degree. The DRC has about 1,500 VMDs and 5,000 veterinary technicians according to The Veterinary Council and the Veterinary Technician Association (2019 unpublished statistics). Most VMDs operate in urban areas. As a result, veterinary technicians provide most of the veterinary services where animal production takes place. We, therefore, understood that veterinary vocational schools, given their number and distribution, are suitable for documenting, monitoring and reporting antibiotic stewardship and educating farmers and the community at large. The aims of this study are: 1) to assess whether veterinary vocational schools could be used as hubs for antibiotics stewardship monitoring, and 2) to determine whether veterinary vocational schools could drive efforts to inform and educate communities, farmers, and future veterinary practitioner on the careful use of antibiotics. The findings of this study provide evidence to support government policies and actions to effectively address the complex and global issue of antimicrobial resistance in a resource constrained country.

Methodology

We conducted this study in Kongo Central Province located in Western DRC which holds 35 veterinary vocational schools, of which 17 were visited. We interviewed in total 17 school male principals and 66 veterinary faculty. Fifteen of the veterinary faculty were females. We used semi-structured interviews, focus group discussions and direct observations to collect data and information on three elements: 1) School administration, 2) School veterinary faculty private and students' practicum and 3) procurement and use of antibiotics in the school catchment area. Faculty were interviewed individually and as focus groups of four people on average. School principals were interviewed separately from faculty to allow more freedom of expression. Personnel from one of the major DRC veterinary drug importers and two local distributors were also interviewed on pharmaceutical acquisition and distribution. The interviews were conducted in French, the official language of the DRC without translator. The research was approved by the Internal Review Board of the Université de Lubumbashi (UNILU) under the approval number

UNILU/CEM/047/2018. All participants signed an informed consent. Collected data were analysed and themes were identified and substantiated by quotations from participants. A SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis was performed to assess the capacity of each school to link up with others to create an effective network to monitor antibiotics stewardship.

Results

We report the result of our study in three categories: 1) School administrative and academic characteristics, 2) Veterinary vocational schools SWOT analysis and 3) Antibiotic stewardship in school catchment areas.

Schools administrative and academic characteristics

All schools visited were government approved and funded. However, they did not have qualified faculty teaching clinical and technical courses per government standards. Faculty assigned to deliver these courses were not VMDs or did not have graduate degrees as recognised by government regulations. All of them were veterinary technicians and in most cases provided veterinary services to farmers in the school catchment areas. In their private practices, 45% worked on small ruminants, 30% on pigs, 28% on fish, 8% on poultry and 7% on cattle. Many of these farms were also sites for students' practicum. Each school had on average 2 to 3 veterinary faculty (males or females). All 35 schools of Kongo Central Province are administered by the Head of the Provincial Veterinary Vocational Education. However, participants reported no interaction between them and schools. These schools are located in 9 of the 10 provincial administrative territories. The Lukula Territory which does not have a veterinary vocational school is less than an hour driving distance from two schools in the neighboring Tshela Territory.

Regarding the curriculum, the veterinary technician education was a four-year program with half of the total course hours allocated to technical and clinical courses. This national curriculum was designed and implemented under the guidelines of the Ministry of Primary, Secondary and Vocational Education. Based on their training, veterinary technicians did not have the same competencies in diagnostic and treatment like veterinary medical doctors. Thus, supervision from veterinary medical doctors is necessary as stipulated by regulations governing the veterinary practices in DRC.

Veterinary vocational school system SWOT analysis

In this section we present the strengths, weaknesses, opportunities, and threats related to the capacity of veterinary vocational schools to serve as a network for monitoring antibiotic stewardship and educating the community, future and current veterinary technicians and farmers.

*Strengths***.** Veterinary vocational schools carry four strengths. The first is the schools' government-given mandate to train veterinary technicians as key contributors to the animal production sector. Second, school faculty deliver the bulk of veterinary services in their catchment areas. Their services include all aspects of veterinary care although performed without VMD supervision. They prescribe antibiotics and other antimicrobials. Although this in not the recommended norm, it is the reality on the ground. A couple of schools have visiting VMD faculty. Most of the practitioners in the schools' catchment areas are faculty from veterinary vocational schools. Third, teachers are well regarded and are community opinion leaders. Fourth, all faculty surveyed expressed interest to participate in an antibiotic stewardship monitoring network. Some expressed the need for financial support to cover the cost of training they need to participate effectively. "*We want to participate even in the training workshops but that may require transportation*". Another faculty said, "*We want to have therapeutic guides as we are missing a lot; it is difficult to teach our veterinary students, especially with regard to infectious diseases: diagnostics and treatment*". It should also be noted that vocational schools are well distributed across the province and the country (Table 1).

*Weaknesses***.** Three weakness should be highlighted. In all schools, faculty in charge of clinical and technical courses were under qualified because they did not hold VMDs or graduate degrees. This under-qualification reflected in their performance, especially in their use of antibiotics. Further, these vocational schools lacked educational resources. Furthermore, school principals lacked the leadership skills necessary to initiate a stewardship monitoring system on their own and many of them did not have a background in animal health and production.

Table 1. Distribution of vocational veterinary schools in Kongo Central Province

District/City	Territory	Number of Schools by Territory
	Tshela	2
Bas Fleuve	Lukula	0
	Seke-Banza	4
Boma/District	Moanda	1
Boma/City	-	1
Matadi/City	-	1
	Songololo	5
Cataractes	Luozi	5
	Mbanza-Ngungu	6
	Kasangulu	1
Lukaya	Madimba	4
	Kimvula	5
Total	-	35

*Opportunitie***s**. Two opportunities were found available to veterinary vocational schools. First, antibiotic resistance (AMR) and antibiotic stewardship were at the forefront of actions carried out in the context of prevention and response to emerging diseases by the government and international donors. Second, the animal health sector was recognised as an important sector to address control of the AMR phenomenon. Therefore, veterinary vocational schools did have an opportunity to positioning themselves as hubs within a network of schools for antibiotic stewardship monitoring and education.

Threats. The important threat facing vocational veterinary school was non-participation in the process of developing a national plan to combat AMR which is yet to get underway. By not being involved in the development of the national AMR control plan, they risk losing a chance to play a key role in the AMR surveillance, given that animal health is a key contributor to antibiotic resistance.

Antibiotics stewardship in veterinary vocational school catchment areas

We report in this section results related to antibiotic stewardship in the catchment areas of veterinary vocational schools.

Knowledge and perceptions on antibiotic resistance

Most veterinary faculty did not have a clear understanding of the determinants of antibiotic resistance. One faculty said, *"I don't have specific knowledge; however, I know the number of resistance cases is increasing"*. The main causes of the emergence of antibiotic resistance identified through interviews were excessive and inappropriate prescription of antibiotics, including overdosing and under-dosing. Some faculty expressed the need to educate themselves and have access to treatment guidelines and continuing education. Faculty interviewed reported cases of resistance to antibiotics observed during their clinical practices, such as therapeutic failures related to penicillin prescribed to heal wounds and other pathologies. They reported that commercial brand of penicillin they use has become ineffective for treating certain pathologies.

The use of laboratories in the diagnosis of diseases

Veterinary faculty from vocational schools interviewed did not use laboratory diagnostic services to guide their practice. The reasons were limited access to the laboratory and clients' expectations for a quick recovery of their animals. Further, the cost of laboratory services was estimated to be too high such that farmers worried about their profit margins. A practitioner said, *"If we had a laboratory nearby, we could have been requesting laboratory confirmation for our diagnostics; instead, we only base our antibiotic choice decision on clinical signs"*.

In their approach to diagnosing illnesses through clinical examinations, veterinary faculty were puzzled by similarity of clinical signs. One faculty commented *"without paraclinical examinations, it is not easy to confirm exactly the cause of the disease"*. Another added that *"especially in poultry, the signs are often identical, but from experience, we always manage to determine the disease"*. They also use their knowledge of pathologies prevalent in their catchment areas as a reference. In most cases, they face pathologies such as Peste de petits ruminants, African swine fever, Anthrax, Rabies and Newcastle disease.

The choice of antibiotics

Our findings show that the choice of antibiotic was based on the availability of products on the markets according to faculty interviewed. The practitioner uses the antibiotic available on the market, not necessarily the one that is right according to the case on hand. One faculty said *"sometimes, we have no choice. No matter which antibiotic is available at the veterinary pharmacy, you buy it"*. Another faculty added *"especially in an emergency. I request from my supplier anything that is an antibiotic to solve an animal health problem*".

Beta-lactams followed by tetracyclines were the families of antibiotics most used by faculty interviewed. Within the beta-lactams, the penicillin molecule, whether combined with oxytetracycline (e.g. penistrepto), was used to deal with viral or bacterial diseases, they reported. One faculty said, *"I use penicillin and streptomycin for infectious diseases such as African swine fever and Peste de petits ruminants, for 5 to 7 days"*. Another faculty added: *"I use tetracycline to treat diarrhea in newborns"*. Faculty also reported the use of these antibiotics for post-operative treatment to prevent infections. One faculty said, *"for me, it's pretty much the same thing; but I increase the dose to treat wounds in animals after castration or other surgery"*. The combination of penicillin and streptomycin is preferred because of its broad spectrum of activity. A faculty said, *"it is an antibiotic that works very well with bacterial pathologies of the respiratory and digestive systems, skin as well as on genito-urinary diseases"*. Another added, *"I don't like being out of penicillin because it treats many bacterial diseases"*. .

Some faculty reported using antibiotics destined to humans. One faculty said, *"I use penicillin marketed for humans to treat animals because of the lack of reliable veterinary pharmacies nearby"*. Another faculty added, *"we have difficulties finding a nearby veterinary pharmacy with good quality products"*.

Antibiotics prescription, dosage, and treatment failures

All faculty interviewed recognised that VMDs are the only animal health providers authorised to prescribe antibiotics. Nevertheless, they argue that under the circumstance where VMDs' supervision is not available, they are taught to prescribe antibiotics. One faculty said that *"normally, it is the VMD who has the right to prescribe antibiotics, and veterinary technicians execute the recommended regimen"*. However, veterinary technicians are often the sole health providers on farms and have no choice but to prescribe antibiotics. Another said, *"I am the sole consultant to all the farms under my responsibility; I perform veterinary procedures such as the diagnosis, drug prescription and administration"*.

One faculty said: *"the small number of VMDs that operate in our province does not even reach the remote areas where we work"*.

To determine the dose to administer, veterinary faculty refer to the drug notice. The challenge, however, was to determine the quantity to administer when the animal weight was not well known. They reported using their experience or the weight tape if available. One faculty also said: *"it is the experience that counts; you can look at an animal and directly determine its weight"*. Another said, *"...it's not easy to find a scale. It is really easy for us to determine the weight by the Quetelet[1] formula or visually."*

In their career as veterinary service providers, faculty interviewed have experienced therapeutic failures. One faculty said, *"I usually treat all kinds of wounds with a combination of penicillin-streptomycin. However, the last time, I had the same type of case of ear wounds in a pig at the same farm, I used the same product, but it didn't work"*. Another added, *"I had a case like this involving a calf. I used the combined penicillin-streptomycin and oxytetracycline to fight the diarrhea of the newborns as I usually do. To my surprise it did not work. There was no effect on the animal which ended up dying"*. Faculty interviewed, although surprised by treatment failure they observed, they did not link it to possible antibiotic resistance. Some said that because of these failures, they have shifted to using newer antibiotics available on the market as older products have become ineffective.

The use of antibiotics as vaccine

The limited access to vaccines in term of availability or affordability coupled with poor disease management skills led to the inappropriate use of antibiotics as a preventive measure. One faculty reported that *"there is a problem with the supply of vaccines to prevent*

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[1] Quetelet formula is used to assess animal live weight (LW) in Kg. LW = 87.5 x T^2 x L, where L is the length of the animal, T the thorax measure both in meter (Delage, Poly & Vissac, 1955, p.225).

animals from all contagious diseases; I use antibiotics instead as a vaccine". The lack of cold-chain infrastructures and electricity were reasons why vaccines were not used. They also indicated that they used antibiotics as a preventive measure in case of unusual mortalities, or when they received epidemiological information related to the prevalence of diseases in their catchment area from colleagues. One faculty said, *"in medicine, prevention is better than treatment. If, for example, my colleagues tell me that there is an epidemic killing animals, I will recommend that the farm owner administer antibiotics to all animals, even to those without signs"*. Another added, *"I prevent diarrhea in piglets with antibiotics at the age of three weeks"*. One more said, *"to prevent illnesses, I use antibiotics for two days and three to five days as a treatment"* while another said, *"to prevent the disease, you only need one or two injections of the antibiotic to avoid the spread of a contagious disease on the farm"*.

The use of antibiotics for animal growth

Most faculty interviewed did not have a clear understanding of the use of antibiotics for animal growth. However, some reported that they have used antibiotics for growth. One faculty said, *"yes, I also use antibiotics to speed up growth in animals"* and another added, *"especially in sick newborns, it is necessary to use antibiotics to increase weight gain"*. They also added that often they administer multivitamins and penicillin-streptomycin or oxytetracycline to improve animal growth.

Antibiotics in the environment and animal products

Animal manure is managed on farms or dumped into the rivers. One faculty said that *"at the farms I manage, manure is kept in the bags and made available to people who need it as fertiliser"*. Another faculty declared that they throw manure from pig farms into the river. Other faculty claim to use a waiting period of about two weeks before using manure as a fertiliser. Regarding the presence of antibiotic residues in meat, the waiting period is seldom respected particularly after the failure of antibiotic therapy. This non-compliance is linked to the decision of farm owners who want to reduce their losses. One faculty said, *"normally one waits 30 days before consuming an animal that has been treated with an antibiotic; unfortunately, farmers do not respect this time frame"*. Another faculty added, *"you can tell farmers to wait before consuming or selling the meat of an animal that has just been treated with the antibiotics, but as soon as you leave the farm, they act otherwise"*.

Veterinary technicians' source of technical information

With regards to sources of information on antibiotics, faculty interviewed reported using several sources, including course notes, drug notices, colleagues, and distributors of pharmaceuticals. *"If I buy a product, I first refer to the packaging leaflet; in the case of difficulties, I ask the person who sold me the drug"* said one faculty. Other faculty said they talk to their colleagues or the provincial veterinarian to get information on the use of antibiotics and on tropical diseases. One faculty said, *"for me, the type of information I seek from well-regarded colleagues often relates to the synergy of antibiotics"*.

Internet searches for information are performed by some faculty. As one of them said, *"I usually use Google when I am in doubt about antibiotic use and infectious diseases"*. Further, information related to livestock production is also disseminated via rural radios. A couple of faculty are presenters on television and radio programs on livestock. As one faculty noted, *"I broadcast in the local language every Wednesday on a local radio and television, a program about good animal husbandry"*.

Antibiotic procurement sources

Through interviews, we identified various actors involved in the supply and distribution of antibiotics. Most antibiotics were imported from Europe, China and India and distributed by private formal and informal retailers and wholesalers. Small retailers sometimes sold antibiotics by the dose to meet the demand of farmers who could not afford to buy a full package given the size of their herds. This practice led to the use of sub-standard antibiotic doses.

Access to quality veterinary pharmaceuticals is a challenge in Kongo Central Province. A faculty said, *"I send money to Kinshasa* [the capital city] *to buy antibiotics"*. There were about three major veterinary pharmaceutical importers and distributors in Kinshasa. Other respondents said they procure veterinary drugs from Matadi, the provincial capital city. In the absence of a veterinary pharmacy, veterinarians reported using antibiotics bought at local pharmacies serving the human population.

Discussion

Our research central question was to assess whether veterinary vocational school as hubs can be organised into a network to monitor and report on antibiotic stewardship in the animal health and production sector.

Further, we wanted to identify the practices and the status of the use of antibiotics in the catchment areas of veterinary vocational schools. The study has shown that veterinary vocational schools in DRC could be organised to monitor antibiotic stewardship. The study results showed that the 17 vocational schools visited, and all the others in DRC, are government approved and funded. The school personnel (principals and faculty) are paid by the government. In each school, at least one faculty holds a veterinary technician degree. Most of veterinary faculty engage in private practice serving farms which also provide field practicum opportunities for their students. A couple of schools have veterinary medical doctors as visiting faculty which is a requirement to fully qualify as faculty for clinical and technical courses. Thus, most veterinary faculty are under-qualified.

This short coming, however, can be easily addressed through political will because of the high number of unemployed or under-employed VMDs in DRC that can be deployed in veterinary vocational schools across the country. It should also be noted that veterinary vocational schools are well distributed across nine of the ten Territories of Kongo Central Province. These schools are centrally managed by the Provincial Head of Veterinary Vocational Education. However, the schools have no interactions with each other. The study has also shown that faculty from vocational schools, although under-qualified, provide most of veterinary services in their catchment areas; thus, they are a crucial force for animal health and production.

Cox (2006) argued that radical solutions to the AMR problems, for instance the complete removal of under-qualified faculty or practitioners, would lead to more issues because such an approach would create a vacuum that would jeopardise human and animal health. Thus, we argue for a stewardship monitoring system that builds upon the status of veterinary vocational schools. Faculty, particularly those with useful technical skills, carry a lot of influence in the community. Therefore, we expect them to be at the forefront of educating farmers, future veterinary technicians, and the population at large. The positive role of schools in driving development has been proven in several countries and well documented in the literature (Appiah & McMahon, 2002). Teachers, especially in rural areas, are opinion leaders, respected and a source of knowledge. Although veterinary faculty represent a small number at each school, if organised into a network and provided with relevant training and information, their influence on antimicrobial medicine use could be extremely valuable in the control of AMR.

Building a network of veterinary schools will require collaboration among them. Established relationships between these schools will facilitate faculty exchange and experience sharing which will result into a network of schools capable of monitoring antibiotic stewardship and providing education. This collaboration could also involve academic institutions and government veterinary services. Whent (1994) and Stephenson, Warnick, & Tarpley (2008) argued that collaboration between academic and vocational schools is important and could be centered on sharing equipment, supplies, information, services, and facilities. However, Whent (1994) noted that barriers such as lack of knowledge on what could be or is available to be shared, physical distance, finding time to devote to collaboration, and lack of institutional support should be taken into consideration. Further, Dormody (1993) indicated that the need for collaboration between vocational and other academic institutions is dictated by the rapid progress observed in sciences and technology. Therefore, he advocated the merger between the theoretical (academic teaching) and the practical (vocational teaching). We argue that given the complexity of antibiotic resistance and stewardship problem, collaboration between academic and vocational faculty will be highly effective in addressing the AMR issues. Furthermore, the proposed collaboration would enhance the quality of vocational education which could also be improved through the allocation of more time to courses related to antibiotic resistance and stewardship.

The second focus of this study was about documenting antibiotic stewardship in the school's catchment areas. In this regard, the study identified critical gaps in knowledge, stewardship of antibiotics and several challenges facing practitioners. These gaps and challenges are like those reported worldwide and are driven by the lack of knowledge and awareness, inadequate training, pharmaceutical promotions, lack of or access to tests, use of leftover drugs stemming from over prescriptions, socio-economic conditions and fear of complications following a treatment (Machowska & Lundborg, 2018). However, these shortcomings could be mediated through capacity building initiatives and supervision or collaboration as mentioned above.

Our findings reinforce the need to set up mechanisms for monitoring antimicrobial stewardship and educating future practitioners and farmers using veterinary vocational schools. Treatment failures reported by respondents are suggestive of cases of antibiotic resistance in their schools' catchment areas. The presence of resistance to antibiotics has been corroborated by a study conducted in DRC by Laboratoire Vétérinaire de Kinshasa – DRC (unpublished report, 2016) which reported resistance of *Staphylococcus spp.*, *Streptococcus spp.* and *Escherichia coli* to penicillin and tetracyclines from many farms in Kinshasa and Kongo Central Province. Thus, antibiotic resistance is a real and significant problem that needs to be addressed. Capacity building of practitioners is, therefore, essential. Asante et al. (2017) noted that lower cadre, such as veterinary technicians and nurses, tend to have poor knowledge of antibiotics resistance. They advocated the provision of formal sources of information to practitioners to address knowledge deficiency. Proper information and treatment guidelines would be useful to build capacity of veterinary practitioners. Our study has shown that pharmacists, well-regarded veterinary technicians, and government veterinarians are sources of information veterinary practitioners consult when in doubt. A mechanism to capitalise on these channels should be designed.

From the interviews of faculty and pharmaceutical distributors, we learned that there are drug vendors who work outside the oversight of government services. As a result, substandard products are widely available leading to the emergence of antimicrobial resistance (Corpet, 1999; Faroult & Alno, 1999). Tracking antibiotic sales will help detect any signal emerging from veterinary practitioner stewardship practices as quickly as possible. The monitoring of practices would make possible the development and implementation of right policies and measures (Chardon & Brugere, 2018). Veterinary faculty from vocational schools, once properly supervised as part of a monitoring network, could notify the authorities of wrongdoing in the antibiotic distribution channels.

Our surveys indicated that penicillin often combined with tetracycline is more often prescribed by veterinarians than other antibiotics. Marie, Martel, Kobisch, Sanders, & Resapath, (2001) reported a similar result saying that penicillin is more prescribed than quinolones and macrolides. This is true for veterinary vocational faculty who are limited by the availability of antibiotics on the market. Given the challenges facing veterinary practitioners in accessing quality antibiotics, chances are that even restricted products, such as those in the class of cephalosporine reserved to humans, could be used in animal health. A limited number of cephalosporins are approved for veterinary usage. A detailed review of cephalosporins approved for veterinary usage are presented in Hornish and Kotarski (2002). The Access to Medicine Foundation published the 2020 Antimicrobials Resistance Benchmark and indicated that in low-income countries, the problem of access to antibiotics is more important than over consumption. Although this is true, antibiotic selection pressure on bacteria is exerted through small doses over time. Thus, even if low antibiotic consumption is reported, one should still be aware of potential antibiotic resistance in the presence of poor stewardship over time. Therefore, monitoring proper use of antibiotics is still essential in the fight against antibiotic resistance.

The presence of antibiotics in the environment is a subject not well understood by many faculty interviewed. The waters and soils are extensively contaminated with drug residues, bacteria and antibiotic resistant genes from farm waste-waters, urban water treatment plants and other sources (Decante, 1999). Faculty interviewed were not able to link manure and farm waste potential role in the emergence and spread of antibiotic resistance. We noticed that environmental aspects of antimicrobial resistance are not properly covered during veterinary technicians' training.

Food products contaminated with microorganisms resistant to antimicrobials or containing antibiotic residues can increase the burden of AMR in humans. Faculty interviewed did not have a good understanding of the presence of resistant bacteria in the environment. However, they know the need for a waiting period before the consumption of products from animals recently treated with antibiotic. Drug packagings clearly label this warning message. Non-compliance with the waiting period is the origin of antibiotic residues found in meat intended for human consumption. Okombe, Luboya, Nzuzi, & Pongombo (2016) reported in a study carried out in the DRC the presence of penicillin and tetracycline residues in liver, gizzard, beef, and chicken samples. The faculty interviewed indicated that they had a good understanding of the importance of respecting the waiting period. However, farmers do not respect the waiting time. Thus, veterinary technicians will have a vital role to play in raising awareness among farmers, particularly if they are part of an antibiotic stewardship monitoring network.

Conclusion

This study suggests that veterinary vocational schools have the potential to promote and monitor antibiotics stewardship in their catchment areas. This is possible because of their mandate as training institutions for key veterinary personnel and as the driving force for the development of the livestock sector. Veterinary faculty from these schools, despite their technical limitations, can be trained, supervised, and supported to collect data and information related to antibiotic stewardship, deliver effective veterinary services, and educate all people involved in the use of antibiotics.

To implement this innovative approach, leadership from outside the veterinary vocational educational system is needed to promote the role these institutions can play in the monitoring of antibiotic stewardship. Financial investments are necessary to bring them up to standards, particularly in terms of infrastructure and equipment. This investment and proposed monitoring role will impact their catchment areas development as well as the livestock sector. The vital role played by schools in educating people, hence driving development, is paramount. The SWOT analysis identified the strengths and opportunities available to implement the proposed innovative approach. If well-trained and educated, faculty from veterinary vocational schools can become providers of information on the proper use of antibiotics. They are also capable of playing a key role in raising awareness among the population and farmers in their catchment areas. By improving their knowledge on antibiotics stewardship, they can collect monitoring data on the use of antibiotics and deliver needed veterinary services even in the absence of VMDs. Further, well trained faculty from veterinary vocational schools will lead to better future workforce. To prevent them from providing veterinary services will create a vacuum that might generate more infections and economic loss.

We, therefore, recommend the following:

1) Develop and implement in-service training for faculty of veterinary vocational school in pharmacology and infectious diseases, with a focus on antibiotics and diseases present in their catchment areas;
2) Mandate the use of treatment registers to better monitor antibiotic use at farms;
3) Recruit and deploy VMDs to vocational veterinary schools to provide the necessary supervision and support;
4) Invest in veterinary vocational school infrastructures and equipment;
5) Develop a network of vocational veterinary schools and develop collaboration with veterinary departments in universities to increase sharing of knowledge, practice and improve student training;
6) Develop treatment guidelines and promote the use of alternative methods to antibiotics;
7) Improve the number of distribution channels and their quality.

Acknowledgement. The authors sincerely thank all participants for their participation.

Competing interests. No conflict of interest.

Funding. This study was funded under USAID Project "One Health Workforce". Grant Number AID-OAA-A-15-00014 made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents are the responsibility of the authors and do not necessarily reflect the views of USAID or the United States Government.

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