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Veterinary drug residues in animal-derived foods: occurrence, veterinary legislation and perceived risk factors in Cameroon

Stanly Fon Tebug[a*] | **Wilfred Angie Abia**[bc] | **Thomas Tumassang Tebug**[d] | **Gabriel Teno**[e] | **Mohamed Mouliom Moctar Mouiche**[f]

[a]International Committee of the Red Cross, Ministries Road, Amarat, Juba, South Sudan.
[b]Department of Biochemistry, Faculty of Science, University of Yaounde 1, Yaounde, Cameroon.
[c]Integrated Risk Assessment Team of the Integrated Health for All Foundation (iRATI-IHAF), Yaounde, Cameroon.
[d]Department of Animal Science, Faculty of Agronomy and Agricultural Sciences, University of Dschang, Cameroon.
[e]New Brunswick Institute for Research, Data and Training (NB-IRDT), University of New Brunswick, Canada.
[f]Department of Pharmacy, Pharmacology and Toxicology, School of Veterinary Medicine and Sciences, University of Ngaoundere, Cameroon.

Corresponding author: stanlytebug@yahoo.com

Abstract The presence of veterinary drug residues in animal-derived foods (ADF) remains a public health concern in low-income countries. In Cameroon, safety standards do not exist and information on exposure levels in both livestock and humans remains scarce. Moreover, awareness among livestock keepers and ADF consumers is low. This paper provides an overview of the current status of antimicrobial (AM) residues in ADF, veterinary legislation on the use of AM, and perception of risk factors with emphasis on the need for sustainable management from a one health perspective. Results show that a wide range of antimicrobials is used with little or no attention to good veterinary practices. Residues of commonly used AM agents, including those banned for use in food animal production in high-income countries, were reported. The current legislation on the use of veterinary drugs is weak and does not make provision for key concepts such as Maximum Residue Limit. Veterinarians argue that the lack of disease diagnostic facilities and excessive use of AM has led to the presence of residues in ADFs. The government and relevant agencies need to enforce regulations for the use of veterinary drugs. Further, awareness creation through educational campaigns for users and consumers as well as the implementation of measures to restrict prescription and dispensation of AM agents to recognized veterinarians are necessary. More studies on AM residues in ADFs are needed to support veterinary drug surveillance policies. This paper strongly suggests collaboration between food safety experts, animal and human health professionals, as well as policymakers to help implement good surveillance of antimicrobial use and to safeguard potent AM suitable for disease control for forthcoming generations.

Keywords: antibiotics, animal sourced-foods, contaminants, one health, risk perception

1. Introduction

In many sub-Saharan African countries, including Cameroon, rapid urbanization and population growth have triggered a high demand for food (Krishna Bahadur et al 2018). Compared to plant-sourced food, the demand for animal-derived foods (ADFs) is also expected to increase considerably with improvement in household income (Enahoro et al 2019). In Cameroon, ADF is estimated to cover over 8% of the total diet of the population per Adult Equivalent (AE). Cooked beef represents 9.86 g/day/EA, chicken 9.81 g/day/AE, and milk 7 g/day/AE (Pouokam et al 2017). In response, livestock farmers seek techniques, including the use of veterinary drugs such as antimicrobial (AM) agents, to improve the efficiency of animal farms (Wouembe 2013). The supply of veterinary medicines in Cameroon is said to be solely dependent on imports (Mouiche et al 2020).

Antimicrobials (AMs) encompass a wide range of chemical substances that are produced naturally, synthetically, or semi-synthetically. These substances are vital in the fight against infections as preventive or curative measures in both humans and animals. In farm animals, AMs are also used as promoters to facilitate efficient production in farm animals (Guetiya Wadoum et al 2016). Most AMs used in veterinary medicine belong to the same classes or surrogates as those used in human therapeutic practices. As defined by Regulation (EC) No. 470/2009 of the European Parliament, residues refer to pharmacologically active substances (active ingredients, excipients, or degraded products) and their metabolites which may remain in ADFs (Tollefson and Miller 2000; Mensah et al 2014). The presence of AM residues in ADFs could be a result of intentional or unintentional mistakes made during drug administration, such as the inability to comply with the dosage or poor

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livestock production practices, amongst others (Mensah et al 2014; Tebug et al 2021). These residues are introduced into the food chain when tissues or products are harvested from these animals as food while still on medication or shortly after medication before the end of the withdrawal period (Tollefson and Miller 2000). Conventional cooking methods are unable to destroy all veterinary drug residues in foods (Canton et al 2019). This could potentially lead to adverse effects on consumers, such as the development of allergies in hypersensitive individuals, increased risk of carcinogenicity, antimicrobial resistance (AMR), and imbalances in intestinal microflora (Nisha 2008). Moreover, it is estimated that the world will lose 3.8% of its annual GDP, 10 million human fatalities annually and 24 million more people may be forced into extreme poverty, a majority of them in low-income countries by 2050 if the use of AMs is not adequately handled (Kraker et al 2016). Thus, existing efforts to manage AM residues would require amelioration to take a multi-disciplinary approach such as the more dynamic and sustainable One Health approach (Collignon and McEwen 2019; Mouiche et al 2019).

While most high-income countries such as the United Kingdom and Germany have effective control and surveillance mechanisms for antimicrobials in both human and animal populations (Maron et al 2013), this is not often the case in most low-income countries such as Cameroon. In these countries, there is insufficient control over the distribution of veterinary pharmaceuticals and phytosanitary products, which are readily available to the public (Guetiya Wadoum et al 2016; Mouiche et al 2020; Tebug et al 2021).

Several contaminants, including toxic metals, mycotoxins (aflatoxins), veterinary drugs' residues, pesticides, and microorganisms, have been reported in Cameroon (Pouokam et al 2017). However, there are limited risk assessment studies, a lack of clear policies, limited information regarding exposure levels in livestock, and a low level of awareness of farmers and consumers, which could favor the irrational use of AMs (Pouokam et al 2017; Tebug et al 2021). In this context, this paper reviews the current legislation on the importation and use of AMs, provides an overview of the current situation of AM residues in ADFs and veterinarians' perception of risk factors for the presence of AM residues in ADFs, with emphasis on the one health approach in preventing and controlling AM residues in ADFs in Cameroon.

2. Materials and Methods

Data for this study was collected through a literature review and cross-sectional survey. The literature review section used both academic and grey literature. Studies and reports published in English and French languages on AMR in Cameroon were accessed from Google Scholar, MEDLINE/PubMed, Science Direct, and Taylor & Francis were used. Meanwhile, grey literature was obtained from ministries in charge of veterinary services as well as websites of relevant organizations such as the National Veterinary Association of Cameroon (Ordre National des Vétérinaires du Cameroun 2021).

The perception of factors that could contribute to the presence of AM residues in ADF in Cameroon was accessed as part of a larger study on health professionals' practices with regards to AM in sub-Saharan Africa (Tebug et al 2021). A questionnaire was developed and hosted on SurveyMonkey™ (SurveyMonkey 2022). Veterinarians in Cameroon were invited to participate in this study between January 15 and February 15, 2020. On opening the link, respondents had access to information about the purpose of this study, its anonymous nature and were asked to consent to participate in the survey. Forty-six veterinarians voluntarily responded to the survey; a majority of the respondent held a Doctor of Veterinary Medicine (DVM) degree (96%), mainly treated food-producing animals (74%) in the last six months and worked in private veterinary practices (46%) (Table 1).

Table 1 Animal health professional's demographics based on an online survey, 2020 (*n* = 46).

Variable	Respondents	
	n	%
Gender		
Female	13	28.3
Male	33	71.7
Qualification		
DVM	44	95.7
Other (livestock Technician, Agricultural Engineer)	2	3.3
Sector		
Private veterinary practice (Clinic)	21	45.6
Other (NGO and animal farms)	12	26.1
University or research organization	13	28.3
Animal species most treated in the past six months		
Food animals	34	73.9
Non-food animals (Pets and wildlife)	12	26.1

Data were summarized using descriptive statistics such as frequencies and proportions. Average ranks for factors that could contribute to AM Residues in ADFs were calculated using the equation 1 below (Almazrou et al 2019):

$$Average\ Rank = \frac{x_1w_1 + x_2\,w_2 + x_nw_n}{Total\ respond\ count} \quad [1]$$

Where:
w = weight of ranked position.
x = response count for the answer of choice.

Weights were applied in reverse order and the answer choice with the largest average ranking is the most preferred, as described previously (Tebug et al 2021).

3. Results and discussion

3.1 Commonly used antimicrobials in food animal production

The main classes of AMs used in the treatment and prevention of infections in food-producing animals are β-lactams, aminoglycosides, tetracyclines, and sulphonamides (Table 2). The quantity of AM used varies across livestock species and livestock production systems, with intensive poultry production accounting for the highest share used, followed by pig, cattle, sheep, and goats (Mouiche et al 2020). This trend could be justified by the increasing demand for ADFs, especially in major cities (Krishna Bahadur et al 2018), which has led to the tremendous transformation from traditional to intensive commercial livestock farming across the country. For example, antibiotics alone amounted to 78.2% of veterinary products sold to farmers by veterinary pharmacies in the West Region in 2011 (Wouembe 2013). Quinolones, sulfonamides, tetracyclines are the most frequently used antimicrobials in poultry farming. These drugs are frequently administered in drinking water and feed by farmers with or without a prescription from a veterinarian (Wouembe 2013; Kamini et al 2016). Meanwhile, fewer antibiotics, mainly tetracyclines and penicillin, are used in cattle and fish farming for therapeutics purposes (Vougat Ngom et al 2017a; Ntsama et al 2018).

Table 2 Frequently used antimicrobials on food animals in Cameroon.

Antimicrobial Class †	Molecules (Derivatives)	Species	Reference
Penicillins	Amoxicillin, Penicillins, Amoxicillin, Ampicillin	Poultry, Cattle	(Ngoune et al 2009; Kamini et al 2016; Vougat Ngom et al 2017ab)
Macrolides	Erythromycin, Tylosin	Poultry	(Ngoune et al 2009; Kamini et al 2016)
Tetracyclines	Doxycycline, Oxytetracycline, Tetracycline	Poultry, Fish, Cattle	(Ngoune et al 2009; Wouembe 2013; Kamini et al 2016; Vougat Ngom et al 2017ab; Ntsama et al 2018)
Polypeptides	Colistin	Poultry	(Ngoune et al 2009; Kamini et al 2016)
Aminoglycoside	Neomycin, Streptomycin, Dihydrostreptomycin	Poultry	(Ngoune et al 2009; Kamini et al 2016)
Quinolones	Ciprofloxacin, Enrofloxacin, Flumequin, Norfloxacin	Poultry	(Ngoune et al 2009; Kamini et al 2016)
Sulfonamides	Sulfamerazine, Sulfadimidine, Sulfadimethoxine, Sulfadiazine	Poultry	(Wouembe 2013; Kamini et al 2016)
Nitrofurans	Furaltadone	Poultry	(Ngoune et al 2009; Wouembe 2013; Kamini et al 2016)
Diaminopyrimidines	Trimethoprim	Poultry	(Kamini et al 2016)

† (World Organisation for Animal Health 2015).

Given that livestock production globally is dynamic, the quantity of AM used in this sector is expected to increase with time, especially in developing countries, to respond to the increasing demand for livestock products. The quantity of AM agents legally imported in Cameroon was estimated at 24.59 tons of active ingredient in 2014. This quantity was more than doubled in 2019 (Mouiche et al 2020) and is expected to increase by about five folds (112 tons) in the next 10 years. These volumes, however, constitute only a fraction of AM agents used on food-producing animals in the country due to the existence of parallel unofficial importation routes of veterinary drugs, a lack of surveillance systems, and the absence of data on the use of antimicrobial by biomass of each animal species. Further, misuse and the existence of poor quality veterinary medicines are known to be the major contributing factors to the presence of residues in ADFs (Mouiche et al 2020).

3.2 Antimicrobial residues in animal-derived foods in Cameroon

There is a huge deficit in the literature on AMs residues in ADFs in low-income countries and the consumption pattern of these chemicals are said to vary from one country to another (Rousham et al 2018; Ngogang et al 2021). While the prevalence of AM residues in ADFs has been controlled to a bare minimum in high-income countries, it is said to be as high as 4 to 90% in food samples examined in developing countries (Maron et al 2013; Mensah et al 2014). Few studies have confirmed the presence of antimicrobial residues in ADFs such as meat, milk, and eggs, including those banned for use in farm animals in Cameroon. A recent study showed that 20.3 % of the 202 liver and muscles samples from cattle in the Far North Region were positive for either penicillin G or oxytetracycline (Vougat Ngom et al 2017a). Of these, 34.14 % of the samples had residues above the Maximum Residue Limit (MRL) established by the EU Commission (European Commission 2010). Another study revealed the presence of Chloramphenicol in chicken destined for human consumption in Cameroon (Guetiya Wadoum et al 2016). Chloramphenicol is a suspected human carcinogen that has been banned for use in food-producing animals in the EU and several high-income countries, including Australia, Canada, Japan, and the USA (Maron et al 2013; Mensah et al 2014). Further, tetracycline, another broad-spectrum antibiotic commonly used in the country (Ngoune et al 2009; Wouembe 2013), was reported in concentrations higher than MRL in poultry sold in the Central Region of Cameroon (Table 3). However, this picture is not unique to Cameroon as AM residues have been reported in many other African countries, including neighboring Nigeria (Adesokan et al 2015).

Considering the nutritive value of ADFs, particularly chicken, beef, and pork, dependence on AM is expectedly high and requires more attention to protect consumers. Ironically, food animal producers continue to use over the counter veterinary drugs (Guetiya Wadoum et al 2016) partly due to ignorance or for economic gains with a consequential detection of residues in these ADFs, which could contribute towards antimicrobial resistance, an emerging food safety concern in Cameroon (Mouiche et al 2019a).

Information assembled in this study emphasized the presence of AM residues mainly in cattle and poultry food products. In line with previous studies (Rousham et al 2018; Ngogang et al 2021), we found out that literature on antimicrobial residues in ADFs in Cameroon is scarce. Reports on their presence focused on foods from cattle and chicken while other livestock species such as pigs and fish, which constitute an important food source in the country was not available.

Table 3 Presence of antimicrobial residues in animal-derived foods in Cameroon.

Molecules	Species	Tissues, organ (ADFs)	Residues concentration in µg/kg (MRL†)	References
Chloramphenicol	Poultry	Muscle	1400 (0)	(Guetiya Wadoum et al 2016)
Oxytetracycline	Cattle	Muscle	240 (100)	(Vougat Ngom et al 2017a)
	Cattle	Milk	(100)	(Edima et al 2012)
Tetracycline	Poultry	Muscle	62,400 (100)	(Guetiya Wadoum et al 2016)
	Poultry	Liver	150,000 (300)	(Guetiya Wadoum et al 2016)
	Poultry	Kidney	8,900 (600)	(Guetiya Wadoum et al 2016)
	Poultry	Gizzard, liver, muscle, eggs	NA	(Keutchatang et al 2019)
Penicillin G	Cattle	Liver	151 (4)	(Vougat Ngom et al 2017a)
	Cattle	Muscle	54 (50)	(Vougat Ngom et al 2017a)
	Cattle	Milk	>4 (4)	(Edima et al 2012)
Streptomycin	Cattle	Milk	NA (200)	(Edima et al 2012)

†, (Nisha 2008; European Commission 2010).

Despite this evidence, possible negative effects of these residues on human health could be neglected, especially given the dearth of information and their inconsistent use across the country. Several studies have revealed the presence of multi-resistant pathogens in chicken sold for human consumption in Cameroon. The most observed resistance was against tetracycline, streptomycin, ampicillin, erythromycin, and to a lesser extent sulphonamides (Ngoune et al 2009; Afnabi et al 2019; Ngogang et al 2021). Further, drug-resistant isolates of *B. cereus* as well as resistant microbes to penicillin G and Oxytetracycline were found in raw milk and milk products and meat in Cameroon (Fossi et al 2017; Afnabi et al 2019). *Bacillus cereus* is known as a leading cause of toxin-induced foodborne, which can manifest itself as an emetic or diarrheal syndrome (Jovanovic et al 2021).

These findings reflect the pattern with which antibiotics are used in poultry and cattle farming across the country (Guetiya Wadoum et al 2016; Vougat Ngom et al 2017b). The presence of these residues in ADFs may constitute a public health risk to consumers of ADFs in Cameroon (Pouokam et al 2017). In this context, further investigations on AM residues in ADFs are needed to foster antimicrobial stewardship. In order to implement good surveillance of antimicrobial use and to safeguard potent AM agents suitable for disease control for future generations, close collaboration between food safety, veterinary professionals, and policymakers are necessary. In response to the poor quality of ADFs in Cameroon, the President of the Republic enacted the draft law on food safety (Law No.2018/020 of December 11, 2018 - Framework Law on Food Safety) after deliberations and adoption by the Parliament of Cameroon (President of the Republic of Cameroon 2018).

3.3 Legislation on the use of antimicrobials in Cameroon

The remarkable increase in antimicrobial resistance (AMR) has become a major concern to both human and animal health in recent years and the drivers are generally studied through farmers and animal health professionals' practices (Mouiche et al 2020; Tebug et al 2021). However, their use largely depends on structural factors, which are often neglected. Privatisation of the veterinary services in most sub-Saharan African countries, for example, came at a time when state veterinary services, as well as legislation governing the use of veterinary medicines, are said to be weak or inexistent (World Organisation for Animal Health 2010). In Cameroon, there is a national registration system for veterinary medicinal products managed by the ministry in charge of veterinary services with a mandate to approve and register all veterinary medicinal products (Van Gool 2015). The legislation governing the practice of the veterinary profession as well as the importation, distribution and use of veterinary medicines are limited to four texts, a non-mandatory standard (Ordre National des Vétérinaires du Cameroun 2021), but lacks a specific regulatory framework for the use of antimicrobial agents.

This first text is Decree N° 90/033 of August 10, 1990, which provides rules for the practice of the veterinary profession in the country. Second, Decree N° 2000/017 of December 19, 2000, regulating veterinary health inspection and Decree N° 2000/018 of December 19, 2000, which provides rules governing the importation, sales, and distribution of veterinary medicines as well as provisions for fighting counterfeiting and irregular practices. This degree indicates that the use of AM is restricted to veterinarians, farmer organizations, and para-veterinarian, but it is simply not implemented and veterinary drugs are often by unauthorized vendors over the counter, as reported previously (Guetiya Wadoum et al 2016). The Degree was amended a decade later by the Prime Ministerial Order N° 2008/2909/PM of December 8, 2008, with the provision of a legal base for manufacturing, packaging as well as specific rules for wholesale and retail of veterinary medicine in the country. The fourth text is the Prime Ministerial order n° 178/CAB/PM of December 5, 2008, which sets the legal basis for the creation and organization of a committee in charge of the approval of new drugs and lastly decree N° 0013 /MINEPIA of July 20, 2010 that regulates the inspection of food of animal origin.

These regulatory texts provide some safety standards with regards to food hygiene and guard against zoonotic diseases but do not cover hazards such as AM residues that require laboratory analysis. Moreover, concepts such as Maximum Residue Limits (MRLs) are not defined by the veterinary legislation in Cameroon. The department of veterinary pharmacy with the mandate to approve and to register all veterinary medicinal products is said to be non-functional mainly because of a lack of structure or human capacity (Van Gool 2015). This confirms findings from previous authors who described food laws in Cameroon as weak or simply not existing (Guetiya Wadoum et al 2016; Pouokam et al 2017).

There are efforts on the way towards improving food safety (quality and control) to protect consumers' health in Cameroon when considering the recently created draft law on food safety in Cameroon (President of the Republic of Cameroon 2018). Specifically, this law provides regulatory principles and foundations for food, feedstuffs for human consumption as well as food additives and supplements, to ensure higher protection of consumers' life, health, and the environment in Cameroon. Although the implementation of legislation governing the use of AM was implemented in EU countries with some obstacles, positive results have been recorded. In Denmark, for example, piglet mortality increased after the restriction on the use of AM but returned to previous levels after 1 year and increased significantly in subsequent years (Institute of Medicine 2010). Thus, setting technical standards and laws as well as periodic inspections and controls in animal health- and in ADF-chains by a joint team of animal health and food safety professionals will help improve the overall quality of food from animal origin across the country.

3.4 Perceived factors contributing to the presence of antimicrobial residues in animal-source foods

Ranking of possible factors that could lead to the presence of AM in ADF was done as described previously (Tebug et al 2021). The lack of veterinary diagnostic facilities and excessive use of AM agents by both animal health practitioners and animal owners were the most important factors that could contribute to the AM residues in ADFs (Table 4). Limited laboratory capacity is said to be a major constraint to the veterinary profession in many low-income countries (Delia 2015), which could, in turn, explain the excessive use of AM agents since treatments are based on clinical diagnosis and experience. Previous studies described the use of AM agents in poultry farms in Cameroon as high, abusive, uncontrolled with little attention to the withdrawal periods (Guetiya Wadoum et al 2016; Kamini et al 2016). Most of these drugs are administered by the farmers themselves, which is fuelled by the availability of veterinary medicine to the general public with or without veterinary prescription (Mouiche et al 2019b).

Raising awareness and improving understanding of AMR is a key strategic objective of the World Health Organisation's global AMR action plan (World Health Organization 2015). When asked about measures to curb AM residues in ADFs, veterinarians also suggest that sensitization of all users on the negative impact of these substances on human health should be the first step in Cameroon (Figure 1). This corroborates with the findings of (Vougat Ngom et al 2017a), who found that a vast majority of respondents (98%) surveyed in northern Cameroon were not aware that meat could be contaminated with AM agents despite the presence of penicillin G and oxytetracycline residues in beef. Meanwhile, the intake for each AM agent was estimated to be 22.81 and 2.37µg per capital for penicillin and oxytetracycline, respectively (Figure 1).

Table 4 Ranking of factors that could contribute to the presence of AM in ADF by veterinarians in Cameroon based on an online survey, 2020 (n = 46).

Factors	Mean rank	Standard deviation	Rank
Lack of diagnostics facilities for animal diseases	2.33	1.41	1
Excessive use of AM agents by veterinarians and animal owners	2.48	1.39	2
Inappropriate use of AM agents (low dose, non-respect of withdrawal period)	2.60	1.55	3
Access and use of AM by animal owners without Veterinary prescription	3.24	1.07	4
Poor sanitation in livestock houses	5.22	1.68	5

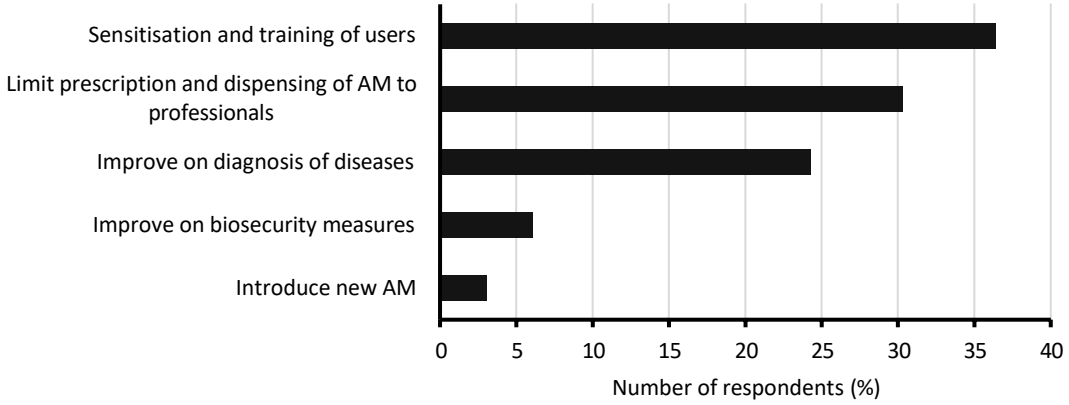

Figure 1 Strategies to curb antibiotic residues in animal-derived food in Cameroon by veterinarians based on an online survey, 2020 (n=46).

According to Baynes et al (Baynes et al 2016) and Nisha (Nisha 2008), intake of penicillin residues can cause allergic reactions, hypersensitivity, and anaphylactic reactions in sensitive consumers. Moreover, studies suggest that the obesity epidemic in the United States could be due to the constant exposure of Americans to food containing low-residue antimicrobial agents through disruption of the equilibrium state of intestinal microbiota (Riley et al 2013). Furthermore, the presence of AM residues in ADFs such as milk, meat, eggs, and fish, can lead to the evolution of resistant pathogens (Fossi et al 2017; Afnabi et al 2019; Ngogang et al 2021), which require a multi-disciplinary approach for a more effective solution.

While optimization of the use of AM in human and animal health are important components of the one health approach in AMR (World Health Organization 2015), a more comprehensive approach should include the environment, aquaculture, and wildlife. Hundreds of thousands of tons of AMs are imported and used annually (Mouiche et al 2020) and a good proportion finds their way into the environment. This could lead to other environmental consequences since litter spilled will enhance the development of multidrug-resistant bacteria (Ngogang et al 2021). Further, the extensive use of manure in integrated fish farming in the country (Ntsama et al 2018) could lead to the reintroduction of resistant microbial and AM residues into the food chain.

To the best of our knowledge, there is no national program to monitor the presence of drug residues in animal products in Cameroon. Further, key concepts such as antimicrobial stewardship are not clearly defined and a national surveillance system on the use of AM does not exist, which could account for the occurrence of residues of common AM in ADFs. However, a framework law on food safety was passed on December 11, 2018. This concern could be addressed through a collaboration between food safety and veterinary professionals. Based on evidence from Austria where fluoroquinolones resistant strains in food animals remain rare due to restricted use in human medicines and its non-approval for use in food animals (Cheng et al 2012), regular control and integrated surveillance system (among the public health, food, and veterinary sectors) for antimicrobials used in animal production, and human health as per the WHO, OIE and FAO's recommendations (World Health Organization 2017) is necessary.

According to Cameroonian veterinarians, limiting prescription and dispensing of all veterinary products to veterinary doctors is the second step to reducing the use and ultimately the presence of AM residues in ADFs. The Cameroonian legislation (Article 17 of Law N° 2000/018 of December 19, 2000) makes provision for sales of veterinary medicines by a range of animal health professionals including veterinary doctors, farmers' associations, para-veterinarians under the supervision of a veterinarian, and state agents. This provision might have contributed to the availability of these drugs to the general public, as observed previously (Van Gool 2015; Guetiya Wadoum et al 2016; Mouiche et al 2019b). The restriction of AM use in food-producing animals in high-income settings is not only associated with reduced residues in ADFs but is also associated with

economic gains, a reduction in the presence of antibiotic-resistant bacteria in animals and humans (Maron et al 2013; Tang et al 2017). In this context, we suggest the need to review national and regional regulations on the use of AM in ADFs since Cameroon is the key actor in food animal production and the only net agricultural exporter of the Central African Sub-region (Nfor et al 2014).

Improvement in the diagnosis of livestock diseases was deemed the third most important strategy to reduce the accumulation of AMs residues in food from animal origin in the country. According to studies involving veterinarians from 25 European and 20 African countries, disease diagnosis, as well as antimicrobial sensitivity tests, strongly influenced their prescription and use of AM (De Briyne et al 2013; Tebug et al 2021). However, laboratory facilities are still lagging in sub-Saharan African countries, including Cameroon (Delia 2015), and veterinarians mainly depend on their skills, experience and clinical signs as a guide to disease diagnosis and treatment in food animals. In addition to the need to establish laboratory facilities in the country, veterinarians think that there is a need for new antimicrobials, which might not be possible in the nearest future given that most pharmaceutical companies abandon their antibiotic research and development due to scientific, regulatory, and economic barriers in recent years (Council of Canadian Academies 2019). In the meantime, the development and use of field-friendly tools such as disease diagnostics tools in Uganda (Eisler et al 2012) or the bodyweight estimation tool for proper use of veterinary drugs in cattle (Tebug et al 2016) could improve on AMU, thereby reducing the accumulation of AM residues in ADF. A reduction in antimicrobial use on farm animals can further be achieved through strict hygiene standards, an improvement in livestock rearing skills and use of ethnoveterinary practices.

Veterinarians can play a key role in safeguarding the judicious use of AM in food-producing animals as a critical control point. However, the inspection, control and management of AM use, AM residues presence in ADFs, as well as the fate of these residues on consumers' health may require a multi-disciplinary collaborative effort constituted of animal health professionals, public health professionals, food safety experts, and policymakers in a one health approach.

4. Conclusions

A significant increase in the demand for foods of animal origin with a subsequent increase in the use of AM is expected in the coming years in low-income countries such as Cameroon. Given the findings of the paper, it is clear that a wide range of antimicrobials is being used across the country with or without prescriptions from a veterinarian. While the information on the burden of AM residues remains scarce, five antimicrobials have been reported in ADFs, mainly in meat from chicken and cattle in Cameroon. Although veterinary legislation on importation and use of AM exists, it is weak or simply not implemented. There is, therefore, a need to raise awareness among key stakeholders, enforce measures that restrict prescription and dispensation of AMs to authorised professionals, and improve diagnostic facilities throughout the country. We also recommend regular screening of ADFs for AM residues supported by grading and prohibition of food containing antibiotics more than MRL or prohibited substances. In addition, more studies on AM residues in ADFs in the country will support decision-making. Considering the interconnections between people, animals, and their shared environment, the collaboration between animal health professionals, public health professionals, food safety experts, and policymakers is necessary to help implement the surveillance of AM use and to safeguard potent AM suitable for disease control for forthcoming generations is necessary.

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