Journal of Animal Science and Veterinary Medicine
Volume 6(5), pages 159-170, October 2021
Article Number: 3D64A7593
ISSN: 2536-7099
https://doi.org/10.31248/JASVM2021.294
https://integrityresjournals.org/journal/JASVM

Full Length Research

Assessment of antimicrobial consumption in food animals in Dar es Salaam, Tanzania

Rogers Azabo[1,2,3]*, Mecky Matee[3,4] and Sharadhuli Kimera[3,5]

[1]Department of Veterinary Microbiology, Parasitology and Biotechnology, College of Veterinary Medicine and Biomedical Sciences, Sokoine University of Agriculture, Morogoro, Tanzania.
[2]National Livestock Resources Research Institute, Kampala, Uganda.
[3]SACIDS Foundation for One Health Sokoine University of Agriculture, Chuo Kikuu Morogoro, Tanzania.
[4]Department of Microbiology and Immunology, School of Medicine, Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania.
[5]Department of Veterinary Public Health, College of Veterinary Medicine and Biomedical Sciences, Sokoine University of Agriculture, Morogoro, Tanzania.

*Corresponding author. Email: rogersazabo@gmail.com; ORCID 0000-0002-0214-314X.

Copyright © 2021 Azabo et al. This article remains permanently open access under the terms of the Creative Commons Attribution License 4.0, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Received 22nd September, 2021; Accepted 13th October, 2021

ABSTRACT: Monitoring antimicrobial use in food-producing animals is one of the global strategies to tackle antimicrobial resistance. The purpose of the present study is to generate quantitative information on antimicrobial use pattern in Dar es Salaam, which will be used as an approach for future monitoring and surveillance of antimicrobial quantities consumed in food animals. A 3 years (2016-2018) retrospective survey of antimicrobial usage in food-producing animals in three selected districts of Dar es Salaam city, Eastern Tanzania was conducted. Data on antimicrobial quantities consumed was obtained from five purposively selected licensed veterinary pharmaceutical sales/outlet establishments in the study area, based on keeping detailed sales records for the study period. Data analysis was done using IBM SPSS version 20. Animal population data were from FAO-Stat database used to extrapolate the quantity consumed in food animals to the entire population during the study period in Tanzania. The antimicrobials were analysed based on class, importance for human medicine and route of administration. The study revealed that 178.4 tonnes of antimicrobials (by weight of active ingredients) were consumed during the 3 years period, with an average of 59.5 ± 3.8 tonnes/year. The commonly consumed antimicrobials were tetracycline (44.4%), sulphonamides (20.3%), aminoglycosides (10.3%) and beta-lactams (7.4%). In relation to veterinary antimicrobial use importance to human medicine, 34.4% were of critically important antimicrobials; 4.1% reserve and 51% watch group according to AWaRe categorization of WHO. Most of the antimicrobials were administered orally. Overall, a mean of 7.44 ± 0.81 mg/PCU (population correction unit) was consumed by food-producing animals during the 3 years period. This finding can help improve monitoring and control of veterinary antimicrobial use in Dar es Salaam in particular and Tanzania in general by preserving the efficacy of antimicrobials for future animal and human generations.

Keywords: Antimicrobial resistance, antimicrobial use, AWaRe categorization, critically important antimicrobial, monitoring, quantities.

INTRODUCTION

Antimicrobials are necessary for treatment, control of animal diseases and its welfare which is similar to human medicine. Their use is essential in sustainable and economically viable animal industry (Acar and Röstel, 2001; SANVAD, 2007). However, extensive antimicrobial use (AMU) in food-producing animals has led to emergence of bacterial strains that are resistant to many antimicrobials (Abdellah et al., 2009). It is envisaged that

foods of animal origin are the potential pathways for the transmission of resistant bacterial strains from livestock to humans (Kimera et al., 2015; Kashoma et al., 2015). It is also known that introduction of some antimicrobial agents has led to an increase of zoonotic resistant bacteria (Tollefson et al., 1998). While some developed countries have demonstrated reduction in usage levels (BelVet-SAC, 2019; DANMAP, 2019), usage in many developing countries have risen due to farm intensification and demand for animal based proteins associated with rising incomes (Van Boeckel et al., 2019; Ström et al., 2017). This puts low- and middle-income countries (LMICs) at a higher risk for emergence of resistance (Ting et al., 2021).

Antimicrobial resistance, and the resulting failure of antimicrobial therapies in humans (Mather et al. 2012), has a greater impact in LMICs due to their weaker health systems, higher prevalence of infectious diseases and limited access to more expensive treatment alternatives (O'Neill, 2016). Since antimicrobial resistance (AMR) is of global concern, the World Health Organization (WHO) in collaboration with the Food and Agricultural Organization (FAO) and World Organization for Animal Health (OIE), has developed a global action plan with a common factor being monitoring and surveillance of antimicrobial use (AMU) in human and agriculture (WHO, 2018a; WHO/FAO/OIE, 2021). The integrated surveillance system is aimed at obtaining accurate data on AMR and AMU across concerned sectors, thus mitigating health hazards and their influence (WHO, 2017). This multi-sectoral strategy, involves initiatives to strengthen monitoring of antimicrobial use in animals (WHO, 2015).

Monitoring of antimicrobial use quantities and usage patterns in food-producing animals enables a country to identify trends of use over time and assess the impact of policy measures to promote prudent use in animals (OIE, 2021). Although OIE has published guidelines for monitoring antimicrobial use in food animals (Góchez et al., 2019), the guidelines acknowledge that data collection can occur at various levels such as imports, manufacturing, sales, dispensing records and end-user sources (Góchez et al., 2019). While several developed countries have been collecting data for a number of years (Hosoi et al., 2013; Grave et al., 2012), many low and middle income countries in Africa and Pacific Asia are still facing challenges like weak regulatory framework, under-reporting and unreliable data when monitoring antimicrobial use in animals (Tiseo et al., 2020).

In Tanzania like any other developing country, the demand for animal proteins is expected to increase within a short period. For instance, it is projected that pork consumption is likely to increase to 170 thousand metric tons from 42.7thousand metric tons between 2017 and 2030, while estimates for annual chicken meat production from 22,000 tons in 2017 to 37,200 tons in 2022 (Michael et al., 2018**b**). This increased demand has not only led to intensified farming systems but also increased antimicrobial use (Wilson and Swai, 2014). In a recent study by Kimera et al. (2020) at Msimbazi River Basin in Dar es Salaam, a high antimicrobial usage for prophylaxis purposes was reported among poultry and pig farmers. Unfortunately, antimicrobial use in food animals in Tanzania faces several challenges among which include a weak regulatory antimicrobial use framework, weak surveillance system, tendency of livestock owners to stock drugs, engagement of unskilled personnel in animal treatment and a high level of drug abuse by livestock keepers (Nonga et al., 2009; Caudell et al., 2017). Although scanty reports describe the Tanzanian situation, the trend of antimicrobial usage in the livestock sector is alarming (Hounmanou and Mdegela, 2017). In the national action plan on antibiotic resistance, year 2017 to 2022, it is indicated that there are high levels of inappropriate use of antimicrobials in the human and animal sectors in Tanzania (MoHCDGEC, 2017). The action plan therefore raises awareness on resistance and promotes prudent antimicrobial use in humans, animals and plants.

In this context, the present study used antimicrobial sales data to assess antimicrobial consumption in food-producing animals in Dar es Salaam thus providing information for future monitoring and development of rational antimicrobial use in Tanzania. This information will enable policy makers to make decisions from an informed view to preserve the efficacy of antimicrobials for future animal and human generations (SANVAD, 2007; Eagar et al., 2012; Mitema et al., 2001).

METHODOLOGY

Study design, site and data source

This study was conducted as a retrospective survey between August and September 2019 in three of the five districts in Dar es Salaam city, Eastern Tanzania. It involved collation of information on quantities of antimicrobials from licensed veterinary pharmaceutical wholesale/outlets based on inclusion criterion. The inclusion criterion was sales establishments with detailed records for 3 consecutive years (2016-2018). These were purposively selected; with one, three and one outlets from Ilala, Kinondoni and Ubungo districts respectively. These districts were selected because of their relatively high livestock species (cattle, goat, sheep, pigs and poultry) and activities. Besides, there are numerous small intensive and semi-intensive livestock farming operations which are characteristic of most households. In addition, unregulated access to veterinary antimicrobials whereby a farmer can decide to purchase and administer drugs without veterinary prescription or supervision.

Data collection

Data was extracted by the researchers based on anatomical

Table 1. Quantities of veterinary antimicrobial (antibiotics) agents, in tonnes of active ingredients, consumed by food animals in Tanzania (2016-2018).

Antimicrobial class	Quantity of active ingredient in tonnes (%) per year			Total /class of drug (%)	Mean± SD (2016-2018)
	2016	2017	2018		
Beta-lactams	4.1 (7.4)	4.5 (7.2)	4.6 (7.6)	13.2 (7.4)	4.4± 0.2
Tetracycline	24.4 (44.1)	28.3 (45.1)	26.5 (43.9)	79.2 (44.4)	26.4±1.9
Aminoglycosides	5.9 (10.7)	6.5 (10.4)	6.0 (9.9)	18.4 (10.3)	6.1±0.3
Macrolides	3.1 (5.6)	3.6 (5.7)	3.7 (6.1)	10.4 (5.8)	3.5±0.3
Nitrofurans	0.9 (1.6)	0.8 (1.3)	1.0 (1.7)	2.7 (1.5)	0.9±0.1
Quinolones	3.6 (6.5)	3.9 (6.2)	3.9 (6.5)	11.4 (6.4)	3.8±0.2
Polymyxins/polypeptides	1.6 (2.9)	1.8 (2.9)	1.7 (2.8)	5.1 (2.9)	1.7±0.1
Sulphonamides & potentiators	11.2 (20.3)	12.7 (20.3)	12.4 (20.5)	36.3 (20.3)	12.1±0.8
Ionophores	0.5 (0.9)	0.6 (1.0)	0.6 (1.0)	1.7 (1.0)	0.6±0.1
Overall tonnes/year (%)	55.3 (100)	62.7 (100)	60.4 (100)	178.4 (100)	59.5±3.8

therapeutic chemical classification system for veterinary medicinal products (ATCvet), proposed by WHO (2012). It included: numbers of vials/bottles packs/tubes or bags, the potency of each antimicrobial drug, the class or combination product, trade name of the antimicrobial, dosage form and indication. Any missing information on the name of active ingredient, potency of each antimicrobial drug and route of administration was obtained from summary product characteristics or internet (technical notes). The antimicrobial agents were classified into 9 groups. The data collection form used is in Appendix Table 1. The data collected was stored on an MS Excel spreadsheet 2007 program.

Animal population data and biomass calculation

Animal data (number of live animals, number of animals slaughtered and quantity of meat product) for biomass calculation was obtained from the Food and Agricultural Organization Global Statistical Database (FAOSTAT) (FAO, 2021). Cattle, sheep, goats, pigs and chicken were considered as the main food producing animals in this study. For poultry, chicken data was considered because domestic production of other birds is lower in Tanzania (Michael et al., 2018a). The national total biomass per year of each species from 2016 to 2018 was calculated using the PCU method (OIE, 2020; OIE, 2017). One PCU was equivalent to 1 kg of livestock biomass and slaughtered animals (EMA, 2018).

Data management and analysis

Data was cleaned, checked for accuracy, completeness and reliability before analysis. The total quantity of each active antimicrobial ingredient (in kilograms), converted to tonnes (t) consumed between 2016 and 2018 was obtained by multiplying the quantitative composition of the active ingredient per unit for each pharmaceutical form (powder, bolus, solution, suspension) by the number of vials/bottles, tubes/packs or bags sold. For active ingredients expressed as an international unit (IU), a conversion factor was applied to calculate tonnes of antimicrobials consumed following the OIE recommendations (EMA, 2018).

For evaluation of veterinary antimicrobial use impact on public health, the antimicrobials were classified as critically important antimicrobial (CIA), highly important antimicrobial (HIA) and important antimicrobial (IA) using the WHO list of critically important antimicrobials for human medicine (WHO, 2018a) and AWaRe (access, watch and re-serve) categorization of WHO (2019). The quantity of antimicrobial agents for animal use for the main livestock biomass was adjusted as follows (EMA, 2018): antimicrobial consumed (mg)/total livestock biomass (kg).

Annual total consumption estimates were presented in mg/PCU for overall food-producing animals (EMA, 2018). Descriptive data analysis was performed using IBM SPSS Statistics (ver. 20.0. Armonk, NY). Antimicrobial consumption trend was done using Spearman rank-order correlation with a significance cut off at 0.05.

Ethical consideration

Ethical approval was obtained from National Institute of Medical Research of Tanzania (Ref #. NIMR/HQ/R.8a/Vol.IX /3233) and ethical committee of Sokoine University of Agriculture (Ref # DPRTC/186/3).

RESULTS

Trends of veterinary antimicrobial usage

The study showed that 178.4 tonnes of antimicrobials were

Figure 1. Proportion of antimicrobial quantities (tonnes of active ingredient) consumed by food animals in Tanzania per route of administration (2016-2018).

consumed by food-producing animals during the three years study period (2016-2018), with an average of 59.5 ± 3.8 tonnes/year. The highest consumption was 62.7 tonnes in 2017 and tetracycline constituted the bulk of antimicrobials consumed during that year. Generally, there was an increase of 8.5% in antimicrobial consumption between 2016 and 2018 (Table 1).

Tetracyclines (44.4%), sulphonamides (20.3%), aminoglycosides (10.3%) and beta-lactams (7.4%) were the most commonly consumed antimicrobial classes by weight of active ingredient (Table 1). The common route of administration of the antimicrobials was oral 68.1%, followed by parenteral 28.9% and then topical 3.0% (Figure 1). Tetracyclines (26.2%), sulphonamides (25.2%), beta-lactams (20.9%) and aminoglycosides (20.7%) were the most common injectables; tetracyclines (52.6%), sulphonamides (17.7%) and quinolones (8.4%) were the common forms of antimicrobials administered orally (Appendix Table 2).

In terms of galenic forms, solid dosage forms accounted for 63.0% of the total quantity of antimicrobials consumed during the three years study period, followed by liquid forms (37.0%). Among the solid forms, tetracyclines (57.0%), sulphonamides (19.7%) and macrolides (7.3%) were the most commonly available antimicrobials in powder form; tetracycline (22.7%), sulphonamides (21.9%), beta-lactams (18.1%) and quinolones (17.0) were the most common product classes in liquid form (Appendix Table 3).

Antimicrobial quantities consumed in food animals in Dar es Salaam, Tanzania in relation to the level of its importance in human medicine.

The present study has shown that over the 3 years study period, 63.7% of the consumed antimicrobials were high important and 34.4% were critically important antimicrobials for human medicine (Table 2). The amount of critically important antimicrobials for human medicine consumed by food animals increased over the study period. For the AWaRe categorization, 4.1% of the antimicrobials consumed during the three years study period was classified in the reserve group, 51% in the watch group and 44.9% in the access group. Antimicrobials in the access, watch and reserve categories increased from 2016 to 2017 and then decreased in 2018 (Table 2).

Antimicrobial quantities adjusted by food animal population

The total estimate of the quantities of antimicrobials consumed by the food-producing animals during the study period adjusted by animal population biomass was 7.44 ± 0.81 mg/PCU (Figure 2, Table 3 and Appendix Table 4). Generally, an increase in antimicrobial consumption was observed.

Tetracyclines (3.31 ± 0.39 mg/PCU), sulphonamides

Table 2. Quantities of antimicrobials consumed classified according to WHO criteria for critically important and AWaRe categorization.

WHO antimicrobial classification		Quantity of active ingredients in tonnes (%)/year			
Class	**Antimicrobial agent**	**2016**	**2017**	**2018**	**2016-2018**
Critically important antimicrobial (CIA)					
Aminoglycosides	Dihydrostreptomycin	3.3(22.0)	3.7(22.3)	3.3(20.5)	10.3(21.6)
	Gentamicin	1.5(10.0)	1.6(9.6)	1.6(9.9)	4.7(9.9)
	Kanamycin	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)
	Neomycin	1.1(7.3)	1.2(7.2)	1.1(6.8)	3.4(7.1)
	Streptomycin	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)
Fluoroquinolones	Enrofloxacin	2.9(19.3)	3.1(18.7)	3.0(18.6)	9.0(18.9)
	Flumequine	0.1(0.7)	0.1(0.6)	0.1(0.6)	0.3(0.6)
	Norfloxacin	0.6(4)	0.7(4.2)	0.8(4.9)	2.1(4.4)
Macrolides	Tylosin	3.1(20.7)	3.6(21.7)	3.7(22.9)	10.4(21.8)
Beta-lactam/penicillin	Amoxicillin	0.8(5.3)	0.8(4.8)	0.8(4.9)	2.4(5.0)
Polymyxins	Colistin	1.6 (10.7)	1.8(10.8)	1.7(10.6)	5.1(10.7)
Total		**15 (100)**	**16.6 (100)**	**16.1(100)**	**47.7 (100)**
Highly important antimicrobial (HIA)					
Beta-lactam/penicillin	Benzyl penicillin	2.9(10.6)	3.3(10.4)	3.0(10.2)	9.2(10.4)
Tetracycline	Chlortetracycline	1.4(5.1)	2.0(6.3)	1.9(6.0)	5.3(6.0)
	Doxycycline	4.7(17.2)	5.3(16.8)	5.1(17.3)	15.1(17.1)
	Oxytetracycline	18.0(65.9)	20.7(65.5)	19.2(65.1)	57.9(65.5)
	tetracycline	0.3(1.1)	0.3(0.9)	0.3(1.0)	0.9(1.0)
Total		**27.3(100)**	**31.6(100)**	**29.5(100)**	**88.4(100)**
Important antimicrobial (IA)					
Polypeptides	Bacitracin	0.0 (0.0)	0.0 (0.0)	0.0(0.0)	0.0(0.0)
Nitrofurans derivatives	Furazolidone	0.9 (100)	0.8(100)	1.0(100)	2.7(100)
Total		**0.9(100)**	**0.8(100)**	**1.0(100)**	**2.7(100)**
WHO AWaRe categorization					
Access					
Penicillin	Amoxicillin	0.8(4.5)	0.8(4.1)	0.8(4.2)	2.4(4.3)
	Ampicillin	0.0(0.0)	0.0(0.0)	0.1(0.5)	0.1(0.2)
	Benzyl penicillin	2.9(16.4)	3.3(17.0)	3.0(15.7)	9.2(16.4)
	Cloxacillin	0.4(2.3)	0.4(2.1)	0.7(3.7)	1.5(2.8)
Tetracycline	Doxycycline	4.7(26.7)	5.3(27.3)	5.1(26.7)	15.1(26.9)
	Tetracycline	0.3(1.7)	0.3(1.5)	0.3(1.6)	0.9(1.6)
Sulphonamide	Sulfadiazine/trimethoprim	5.4(30.7)	6.0(27.3)	5.8(26.7)	17.2(26.9)
	Sulfamethoxazole/trimethoprim	3.1(17.6)	3.3(17.0)	3.3(17.3)	9.7(17.3)
Total		**17.6(100)**	**19.4(100)**	**19.1(100)**	**56.1(100)**
Watch					
Aminoglycosides	Neomycin	1.1(5.6)	1.2(5.3)	1.1(5.2)	3.4(5.3)
Fluoroquinolones	Flumequine	0.1(0.5)	0.1(0.4)	0.1(0.5)	0.3(0.5)
	Norfloxacin	0.6(3.0)	0.7(3.1)	0.8(3.8)	2.1(3.3)
Tetracycline	Oxytetracycline	18.0 (90.9)	20.7(91.2)	19.2 (90.6)	57.9(90.9)
Total		**19.8(100)**	**22.7(100)**	**21.2(100)**	**63.7(100)**
Reserve					
Polymyxins	Colistin	1.6(100)	1.8(100)	1.7(100)	5.1(100)
Total		**1.6(100)**	**1.8(100)**	**1.7(100)**	**5.1(100)**

(1.51 ± 0.16 mg/PCU), aminoglycosides (0.77 ± 0.11 mg/PCU) and beta-lactams (0.55 ± 0.04 mg/PCU) were the most commonly used antimicrobial classes by animal biomass (Table 3). There was significant negative decrease monotonic trend in antimicrobials sold based on weight adjusted by biomass (rs – 1, p value 0.01).

Figure 2. Antimicrobial quantities consumed (mg) adjusted by food animal biomass (PCU) in Tanzania, 2016-2018.

Table 3. Quantity of antimicrobial (mg) per population correction unit by antimicrobial classes in Tanzania, 2016-2018.

Antimicrobial class	Veterinary antimicrobial consumed in mg per PCU			Spearman rank correlation	Mean±SD
	2016	2017	2018	r(p-value)	2016-2018
Beta-lactams	0.58	0.56	0.5	-1(0.01)	0.55±0.04
Tetracycline	3.51	3.55	2.86	-0.5(0.67)	3.31±0.39
Aminoglycosides	0.85	0.82	0.65	-1(0.01)	0.77±0.11
Macrolides	0.44	0.45	0.4	-0.5(0.67)	0.43±0.03
Nitrofurans	0.13	0.1	0.11	-0.5(0.67)	0.11±0.02
Quinolones	0.52	0.49	0.42	-1(0.01)	0.48±0.05
Polymyxins/polypeptides	0.23	0.23	0.18	-0.8(0.33)	0.21±0.03
Sulphonamides & potentiators	1.61	1.59	1.33	-1(0.01)	1.51±0.16
Ionophores	0.07	0.08	0.06	-0.5(0.67)	0.07± 0.01
Total	7.94	7.87	6.51	-1(0.01)	7.44±0.81

DISCUSSION

Assessment of antimicrobial consumption (AMC) in food animals in Dar es Salaam, Tanzania between 2016 and 2018 in the current study revealed; an increase in the quantities of antimicrobials (antibiotics) consumed; high consumption of 62.7 tonnes in 2017; tetracyclines, sulphonamides, aminoglycosides and beta-lactams as the most commonly used antimicrobials; oral route as the preferential antimicrobial route of administration, critically important, reserve and watch antimicrobials are often used in food animals, on adjustment by animal population biomass, an estimate total of antimicrobial consumed was 7.44 ±0.81 mg/PCU. Evaluation of AMC raises awareness on AMR development and comparison of data with other countries. Reporting on AMU in food producing animals is important in identification, conducting of risk assessment, integration of resistance data and evaluation of effectiveness of measure to manage antimicrobial usage (Werner et al., 2018).

The increasing trend in the quantities of antimicrobials consumed suggests intensification of poultry and pig production in Tanzania to meet the demand for short-cycle animal stocks (Rugumisa et al., 2016; Kimbi et al., 2015). During the period 2016-2018, the antimicrobial consumption increased by 8.5% although it is low compared to other studies elsewhere in Africa, Mouiche et al. (2020) reported a percentage increase of 104%. This

finding is in line with the global consumption of antimicrobials (antibiotics) in livestock. Van Boeckel et al. (2015) estimated an increase of 67% consumption worldwide between 2010 and 2030. They reported that up to one-third of the rise in consumption in livestock would be attributed to a shift from the current widespread extensive farming systems to intensive farming operations in middle-income countries which involve use of antimicrobials at sub-therapeutic doses. Antimicrobial quantity in the present study was an underestimation of the actual situation since the official figures do not exist for antimicrobial agents that illegally enter Tanzania and probably outweigh the official numbers (Hounmanou and Mdegela, 2017).

A high observed consumption of 62.7 tonnes of antimicrobials in 2017 probably suggests that increased antimicrobial consumption rate was driven by increased livestock population (Michael et al., 2018**a**) thus increasing chances of antimicrobial resistance risk. This is in agreement with the work done by Mitema et al. (2001) whereby they associated increased consumption with increased livestock population. However, it is in contrast with the work done elsewhere in Africa by Adesokan et al. (2015) who reported increased consumption rate to be driven by other factors rather than increased animal population. The matters of concern were livestock disease management practices and livestock production in general.

Similar with the findings reported in other studies in Tanzania (Caudell et al., 2017) and elsewhere in Africa (Mitema et al, 2001; Tufa et al., 2018), tetracyclines, sulphonamides, aminoglycosides and beta-lactams were the antimicrobial classes most widely used in food animals in the present study. Quantities of tetracycline consumed were higher than the 28.7% (3.08 tonnes) reportedly used in the OIE-African region (OIE, 2020). Tetracyclines are a class of antimicrobials which are common among farmers and veterinarians because of their broad-spectrum antimicrobial activity, availability over the counter without prescription and affordability. They are used extensively in the treatment of rickettsias, erlchiasis, mycoplasma, anaplasmosis (Prescott, 2000) and initial stages of theileriosis and also as growth promoters in pigs and poultry farms (Chinchilla and Rodriguez, 2017). It is possible that its soluble form used in treatment, accounts for the high consumption observed in this study. However, they are generally not used for enteric diseases caused by *Escherichia coli* or *Salmonella spp*, as these bacteria are often resistant to them (Harada et al., 2005; Kawagoe et al., 2007).

Sulphonamides were the second group of commonly used antimicrobials in this study. This class of antimicrobials are popularly used in poultry production in the control of coccidiosis especially in broilers and colibacillosis (Mitema et al., 2001). They are also extensively used in the treatment of calf scours and pneumonia (Mitema et al., 2001). This extensive usage in food-producing animals is probably responsible for the high quantities consumed in the present study.

Aminoglycosides were another group of antimicrobials encountered in this study. They are very important pharmacotherapeutic armamentarium in human medicine (Mitema et al., 2001). However, overuse of this group of agents in food animals may impact antimicrobial resistance in human pathogens. Although antimicrobial consumptions have greatly reduced in European countries in food animals due to national campaigns that encourages appropriate use, in low-and middle-income countries such as Tanzania, there is unregulated antimicrobial use due to a weak regulatory framework (Karimuribo et al., 2005).

In this study, 68.1% of the antimicrobials intended for animal health were administered orally, slightly lower than in the study by Mouiche et al. (2020) who reported administration of 73.1% (217.67 tonnes) of antimicrobials by the oral route in Cameroon. The oral route is prioritized for mass medication and thus low risks of intoxication from high antimicrobial intake as compared to the parenteral route. However, in a study elsewhere by Simoneit et al. (2015), they demonstrated that the oral route is prone to misuse due to inappropriate dosing and thus promotes development of antimicrobial resistance. Oral route permits solid, semi consistent and liquid forms of antimicrobials to be taken through drinking water and with feed (Tsutsui et al., 2018). Furthermore, it does not require expertise thus favouring auto medication of animals by farmers. The observed oral route preference in the present study explains the higher proportions of powder pharmaceutical forms consumed (Mouiche et al., 2020).

High consumption of critically important antimicrobials in human medicine was observed in the present study over the 3 years period surveyed. This concurs with the findings by Callens et al. (2012) in Belgium who reported that 47.7% of critically important antimicrobials (antibiotics) in human medicine were used in pig production. Similarly, increased use of antimicrobials classified as reserve and watch group as categorized by WHO were also noted. Use in the watch group comprises of a broad spectrum of antibiotic classes corresponding to those of high priority agents on the list of critically important antimicrobials used in human medicine; use of reserve group comprises of last resort antibiotics that target multidrug-resistant infections (Hsia et al., 2019). The use of critically important antimicrobials and the reserve group of human antimicrobial agents in food-producing animals/livestock was probably due to lack of awareness by the farmers on the implications of antimicrobial resistance on public health (Tufa et al., 2018). Therefore, there is need to sensitize the farmers through mass media to empower and enhance their knowledge on antimicrobial use. Alternative disease prevention and control strategies like vaccination could be a better option (Lhermie et al., 2017). Furthermore, reinforcement of antimicrobial regulatory framework would reduce inappropriate usage in food animals and hence

development of resistance.

In the present study, on adjustment for animal population biomass; the result obtained was slightly higher than that reported in the OIE Africa region (6.46 mg/PCU) (OIE, 2020), but lower than that reported in Vietnam (247.3 mg/PCU) when compared (Carrique-Mas et al., 2020). Overall, the quantities of active substances used in food-producing animals increased by 8.5% from 2016 to 2018 in Tanzania.

In the current study, the findings above notwithstanding, had some limitations. In the first place, the data used to estimate the animal population biomass obtained from the FAO-stat database might have underestimated the actual situations since we could not access reliable data from the Directorate of Veterinary Services of Tanzania. In addition, quantities of antimicrobial consumed might have been underestimated owing to non-existent official figures of antimicrobial agents used by farmers that enter illegally into Tanzania (Hounmanou and Mdegela, 2017). Furthermore, due to the sensitive nature of the information requested, most importers/wholesalers thought that it was an indirect way of assessing their non-compliance to tax returns during the study period and thus did not comply this could have also contributed to the underestimation of quantities consumed.

The data obtained was aggregated, it was difficult to cater for season variations in terms of quantities consumed. This is important in terms of antimicrobial prudent use. Also, since most veterinary antimicrobials are licensed for multiple species administration, the quantity consumed by each animal species during the study period could not be estimated.

Conclusions and Recommendations

Assessment of antimicrobial consumption in food animals is vital as it provides a benchmark for policy makers to make decisions from an informed point of view to preserve the efficacy of antimicrobials for future animal and human generations. Furthermore, it provides necessary evidence for the application of WHO, OIE and FAO recommendations against AMR.

Future directions: Improving farmers' access to professional animal health workers and training of animal health professionals to engage with farmers has been shown to be effective elsewhere as far as prudent antimicrobial use is concerned. Future monitoring could be directed towards data collection at farm level to explain species and production type use pattern.

CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

ACKNOWLEDGMENTS

We acknowledge the veterinary pharmaceutical wholesalers/outlet owners who gave us access to the sales records for the period 2016-2018. We also acknowledge the Government of Tanzania in collaboration with the World Bank (WB-ACE II Grant PAD1436) for funding the study through SACIDS foundation for One Health, Sokoine University of Agriculture, Morogoro, Tanzania.

REFERENCES

Abdellah, C., Fouzia, R. F., Abdelkader, C., Rachida, S. B., & Mouloud, Z. (2009). Prevalence and antimicrobial susceptibility of Salmonella isolates from chicken carcasses and giblets in Meknés, Morocco. *African Journal of Microbiology Research*, 3(5), 215-219.

Acar, J., & Rostel, B. (2001). Antimicrobial resistance: an overview. *Revue Scientifique et Technique-Office International des Epizooties*, 20(3), 797-810.

Adesokan, H. K., Akanbi, I. M., Akanbi, I. O., & Obaweda, R. A. (2015). Pattern of antimicrobial usage in livestock animals in south-western Nigeria: The need for alternative plans. *Onderstepoort Journal of Veterinary Research*, 82(1), 1-6.

BelVet-SAC (2019). Belgium Veterinary Surveillance of Antimicrobial Consumption: National Consumption Report. Retrieved 21 February 2021 from https://belvetsac.ugent.be/BelvetSac_report_2019.pdf.

Callens, B., Persoons, D., Maes, D., Laanen, M., Postma, M., Boyen, F., Haesebrouck, F., Butaye, P., Catry, B., & Dewulf, J. (2012). Prophylactic and metaphylactic antimicrobial use in Belgian fattening pig herds. *Preventive Veterinary Medicine*, 106(1), 53-62.

Carrique-Mas, J. J., Choisy, M., Van Cuong, N., Thwaites, G., & Baker, S. (2020). An estimation of total antimicrobial usage in humans and animals in Vietnam. *Antimicrobial Resistance & Infection Control*, 9, Article number 16.

Caudell, M. A., Quinlan, M. B., Subbiah, M., Call, D. R., Roulette, C. J., Roulette, J. W., Roth, A., Matthews, L., & Quinlan, R. J. (2017). Antimicrobial use and veterinary care among agro-pastoralists in Northern Tanzania. *PloS one*, 12(1), e0170328.

Chinchilla, G. F., & Rodriguez, C. (2017) Tetracyclines in food and feeding stuffs: from regulation to analytical methods, bacterial resistance, and environmental and health implications. *Journal of Analytical Methods in Chemistry*, Volume 2017, Article ID 1315497, 24 pages.

Eagar, H., Swan, G., & Van Vuuren, M. (2012). A survey of antimicrobial usage in animals in South Africa with specific reference to food animals. *Journal of the South African Veterinary Association*, 83(1), Article number 16.

European Medicines Agency (EMA) (2018). European Surveillance of Veterinary Antimicrobial Consumption (ESVAC). Sales of veterinary antimicrobial agents in 30 European countries in 2016. Eighth ESVAC report. Amsterdam.

Food and Agriculture Organization of the United Nations (FAO) (2021). Live animals in the United Republic of Tanzania: Stocks. Retrieved 10 January 2021 from http://www.fao.org/faostat/en/#data/QA.

Góchez, D., Raicek, M., Pinto Ferreira, J., Jeannin, M., Moulin, G., & Erlacher-Vindel, E. (2019). OIE annual report on anti-microbial agents intended for use in animals: Methods used. *Frontiers in Veterinary Science*, 6, 317.

Grave, K., Greko, C., Kvaale, M. K., Torren-Edo, J., Mackay, D., Muller, A., & Moulin, G. (2012). Sales of veterinary antibacterial

agents in nine European countries during 2005–09: Trends and patterns. *Journal of Antimicrobial Chemotherapy*, 67(12), 3001-3008.

Harada, K., Asai, T., Kojima, A., Oda, C., Ishihara, K., & Takahashi, T. (2005). Antimicrobial susceptibility of pathogenic Escherichia coli isolated from sick cattle and pigs in Japan. *Journal of Veterinary Medical Science*, 67(10), 999-1003.

Hosoi, Y., Asai, T., Koike, R., Tsuyuki, M., & Sugiura, K. (2013). Use of veterinary antimicrobial agents from 2005 to 2010 in Japan. *International Journal of Antimicrobial Agents*, 41(5), 489-490.

Hounmanou, Y. M. G., & Mdegela, R. H. (2017). Current situation for antimicrobial use, antimicrobial resistance and antimicrobial residues in the food and agriculture sectors in Tanzania: A review. *Tanzania Veterinary Association Proceedings*, *35*, 58-62.

Hsia, Y., Lee, B. R., Versporten, A., Yang, Y., Bielicki, J., Jackson, C., Newland, J., Goossens, H., Magrini, N., Sharland, M., & Dedeic-Ljubovic, A. (2019). Use of the WHO Access, Watch, and Reserve classification to define patterns of hospital antibiotic use (AWaRe): an analysis of paediatric survey data from 56 countries. *The Lancet Global Health*, 7(7), e861-e871.

IBM Corp (Released 2011). IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.

Karimuribo, E. D., Mdegela, R. H., Kusiluka, L. J. M., & Kambarage, D. M. (2005). Assessment of drug usage and antimicrobial residues in milk on smallholder farms in Morogoro, Tanzania. *Bulletin of Animal Health and Production* in Africa, 53(4), 234-241.

Kashoma, I. P., Kassem, I. I., Kumar, A., Kessy, B. M., Gebreyes, W., Kazwala, R. R., & Rajashekara, G. (2015). Antimicrobial resistance and genotypic diversity of Campylobacter isolated from pigs, dairy, and beef cattle in Tanzania. *Frontiers in Microbiology*, 6, 1240.

Kawagoe, K., Mine, H., Asai, T., Kojima, A., Ishihara, K., Harada, K., Ozawa, M., Izumiya, H., Terajima, J., Watanabe, H., Honda, E., Takahashi, T., & Sameshima, T. (2007). Changes of multi-drug resistance pattern in Salmonella enterica subspecies enterica serovar Typhimurium isolates from food-producing animals in Japan. *Journal of Veterinary Medical Science*, 69(11), 1211-1213.

Kimbi, E., Lekule, F., Mlangwa, J., Mejer, H., & Thamsborg, S. (2015). Smallholder pigs production systems in Tanzania. *Journal of Agricultural Science and Technology,* A, 5(1), 47-60.

Kimera, Z. I., Mdegela, R. H., Mhaiki, C. J., Karimuribo, E. D., Mabiki, F., Nonga, H. E., & Mwesongo, J. (2015). Determination of oxytetracycline residues in cattle meat marketed in the Kilosa district, Tanzania: research communication. *Onderstepoort Journal of Veterinary Research*, 82(1), 1-5.

Kimera, Z. I., Mshana, S. E., Rweyemamu, M. M., Mboera, L. E., & Matee, M. I. (2020). Antimicrobial use and resistance in food-producing animals and the environment: An African perspective. *Antimicrobial Resistance and Infection Control*, 9, Article number 37.

Lhermie, G., Gröhn, Y. T., & Raboisson, D. (2017). Addressing antimicrobial resistance: an overview of priority actions to prevent suboptimal antimicrobial use in food-animal production. *Frontiers in Microbiology*, *7*, 2114.

Mather, A. E., Mathews, L., Mellor, D. J., Reeve, R., Denwood, M. J., Boerlin, P., Reid-Smith, R. J., Brown, D. J., Coia, J. E., Browning, L. M., Haydon, D. T., & Reid, S. W. J. (2012). 'An ecological approach to assessing the epidemiology of antimicrobial resistance in animal and human populations', *Proceedings of the Royal Society B*, 279, 1630-1639.

Michael, S., Mbwambo, N., Mruttu, H., Dotto, M., Ndomba, C., da Silva, M., Makusaro, F., Nandonde, S., Crispin, J., & Shapiro, B. (2018a). Tanzania livestock sector analysis (2016/2017–2031/2032). Retrieved from https://hdl.handle.net/10568/100527.

Michael, S., Mbwambo, N., Mruttu, H., Dotto, M., Ndomba, C., da Silva, M., Makusaro, F., Nandonde, S., Crispin, J., Shapiro, B., Desta, S., Nigussie, K., Negassa, A. & Gebru, G. (2018b). Tanzania livestock master plan. Retrieved 23 October 2019 from https://cgspace.cgiar.org/bitstream/handle/10568/92405/livestockMasterPlan.Tanzania.pdf?sequence=1.

Ministry of Health Community Development Gender Elderly and Children (MoHCDGEC) (2017). The national action plan on anti-microbial resistance 2017 - 2022. The United Republic of Tanzania.

Mitema, E. S., Kikuvi, G. M., Wegener, H. C., & Stohr, K. (2001). An assessment of antimicrobial consumption in food producing animals in Kenya. *Journal of Veterinary Pharmacology and Therapeutics*, 24(6), 385-390.

Mouiche, M. M. M., Moffo, F., Betsama, J. D. B., Mapiefou, N. P., Mbah, C. K., Mpouam, S. E., Penda, R. E., Ciake, S. A. C., Feussom, J. M. K., Kamnga, Z. F., & Awah-Ndukum, J. (2020). Challenges of antimicrobial consumption surveillance in food-producing animals in sub-Saharan African countries: Patterns of antimicrobials imported in Cameroon from 2014 to 2019. *Journal of Global Antimicrobial Resistance*, 22, 771-778.

National Food Institute; Statens Serum Institute (DANMAP 2019). The Danish approach to surveillance of the use of antimicrobial agents and the occurrence of antimicrobial resistance in bacteria from food animals, food and humans in Denmark. Retrieved 21 February 2021 from https://www.danmap.org/-/media/sites/danmap/downloads/data_for_action.pdf?la=da&hash=391F225BB52EC8F60352EEF37A0385E13E1F87E1.

Nonga, H. E., Mariki, M., Karimuribo, E. D., & Mdegela, R. H. (2009). Assessment of antimicrobial usage and antimicrobial residues in broiler chickens in Morogoro Municipality, Tanzania. *Pakistan Journal of Nutrition*, 8(3), 203-207.

O'Neill, J. (2016). Tackling drug-resistant infections globally: Final report and recommendations. Government of the United Kingdom: London, UK.

Prescott, J. F. (2000). Tetracyclines. In: Prescott, J. F., Baggot, J. D., Walker, R. D. (eds.). *Antimicrobial therapy in veterinary therapy*, 3rd edition Ames: Iowa State University Press. Pp. 215-289.

Rugumisa, B., Call, D., Mwanyika, G., Subbiah, M., & Buza, J. (2016). Comparison of the prevalence of antibiotic-resistant Escherichia coli isolates from commercial-layer and free-range chickens in Arusha district, Tanzania. *African Journal of Microbiology Research,* 10(34), 1422-1429.

Simoneit, C., Burow, E., Tenhagen, B. A., & Käsbohrer, A. (2015). Oral administration of antimicrobials increase antimicrobial resistance in E. coli from chicken–a systematic review. *Preventive veterinary medicine*, 118(1), 1-7.

South African National Veterinary Surveillance and Monitoring Programme for Resistance to Antimicrobial Drugs (SANVAD) (2007). University of Pretoria and ARC-Onderstepoort Veterinary Institute. Pretoria, ISBN: 978-1-86854-673-2.

Ström, G., Halje, M., Karlsson, D., Jiwakanon, J., Pringle, M., Fernström, L. L., & Magnusson, U. (2017). Antimicrobial use and antimicrobial susceptibility in Escherichia coli on small-and

medium-scale pig farms in north-eastern Thailand. Antimicrobial Resistance and Infection Control, 6, Article number 75.

Ting, S., Pereira, A., Alves, A. D. J., Fernandes, S., Soares, C. D. C., Soares, F. J., Henrique, O. D. C., Davis, S., Yan, J., Francis, J. R., & Jong, J. B. D. C. (2021). Antimicrobial Use in Animals in Timor-Leste Based on Veterinary Antimicrobial Imports between 2016 and 2019. *Antibiotics*, 10(4), 426.

Tiseo, K., Huber, L., Gilbert, M., Robinson, T. P., & Van Boeckel, T. P. (2020). Global trends in antimicrobial use in food animals from 2017 to 2030. *Antibiotics*, 9(12), 918.

Tollefson, L., Angulo, F. J., & Fedorka–Cray, P. J. (1998). National surveillance for antibiotic resistance in zoonotic enteric pathogens. *Veterinary Clinics of North America: Food Animal Practice*, 14(1), 141-150.

Tsutsui, A., Yahara, K., & Shibayama, K. (2018). Trends and patterns of national antimicrobial consumption in Japan from 2004 to 2016. *Journal of Infection and Chemotherapy*, 24(6), 414-421.

Tufa, T. B., Gurmu, F., Beyi, A. F., Hogeveen, H., Beyene, T. J., Ayana, D., Woldemariyam, F. T., Hailemariam, E., Gutema, F. D., & Stegeman, J. A. (2018). Veterinary medicinal product usage among food animal producers and its health implications in Central Ethiopia. *BMC veterinary research*, 14, Article number 409.

Van Boeckel, T. P., Brower, C., Gilbert, M., Grenfell, B. T., Levin, S. A., Robinson, T. P., Teillant, A., & Laxminarayan, R. (2015). Global trends in antimicrobial use in food animals. *Proceedings of the National Academy of Sciences*, 112(18), 5649-5654.

Van Boeckel, T.P., Pires, J., Silvester, R., Zhao, C., Song, J., Criscuolo, N.G., Gilbert, M., Bonhoeffer, S., & Laxminarayan, R. (2019). Global trends in antimicrobial resistance in animals in low- and middle-income countries. *Science*, 365, 1944.

Werner, N., McEwen, S., & Kreienbrock, L. (2018). Monitoring antimicrobial drug usage in animals: methods and applications. In: *Antimicrobial Resistance in Bacteria from Livestock and Companion Animals*, Pp. 569-594.

Wilson, R. T., & Swai, E. S. (2014). Pig Production in Tanzania: A critical review. *Tropicultura*, 32(1), 46-53.

World Health Organization (WHO) (2012). Collaborating Centre for Drug Statistics Methodology. ATCvet. Retrieved 12 September 2012 from www.whocc.no/atcvet/atcvet/.

World Health Organization (WHO) (2015). Global action plan on antimicrobial resistance. World Health Organization: Geneva, Switzerland.

World Health Organization (WHO) (2017). Integrated surveillance of antimicrobial resistance in food borne bacteria: application of a one health approach. Retrieved from https://apps.who.int/iris/bitstream/handle/10665/255747/9789241512411eng.pdf?Sequence=9789241512411.

World Health Organization (WHO) (2018a). Critically important antimicrobials for human medicine: ranking of medically important antimicrobials for risk management of antimicrobial resistance due to non-human use. 6th revision. Retrieved from https://www.who.int/foodsafety/publications/ antimicrobials-sixth/en.

World Health Organization (WHO) (2018b). Global antimicrobial resistance surveillance system (GLASS) report: early implementation 2016–2017. Retrieved 29 January 2018 from https:// www.who.int/glass/resources/publications/early-implementation-report/en.

World Health Organization (WHO) (2019). WHO releases the 2019 AWaRe classification antibiotics. Retrieved September 3, 2020 from https://www.who.int/medicines/news/2019/WHO_releases2019AWaRe_classification_antibiotics/en/.

World Health Organization, Food and Agriculture Organization of the United Nations & World Organisation for Animal Health (WHO/FAO/OIE) (2021). Monitoring global progress on antimicrobial resistance: tripartite AMR country self-assessment survey (TrACSS) 2019–2020: global analysis report. World Health Organization. Retrieved from https://apps.who.int/iris/handle/10665/340236.

World Organisation for Animal Health (OIE) (2021). Monitoring of the quantities and usage patterns of antimicrobial agents used in food-producing animals (Chapter 6.9). In: *Terrestrial animal health code*. Retrieved 16 February 2021 from https://www.oie.int/en/what-we-do/standards/codes-and-manuals/terrestrial-code-online-access/?id=169&L=0&htmfile=chapitre_antibio_monitoring.htm

World Organization for Animal Health (OIE) (2017). Annual report on antimicrobial agents intended for the use in animals: better understanding of the global situation Second Report. Paris.

World Organization for Animal Health (OIE) (2020). Annual report on antimicrobial agents intended for use in animals: better understanding of the global situation. Fourth Report. Paris.

Appendix

Appendix Table 1. Data collection form on quantities of antimicrobials sourced at the Veterinary Pharmaceutical wholesaler or outlet from 2016-2018.

Antimicrobial class	Active Pharmaceutical Ingredient (API)	Number of vials/ bottles/packs	Active ingredient (Kg)	Dosage form	Indication (species & if for t, p &gp)
Beta-lactams	ampicillin, amoxicillin, cloxacillin, Benzylpenicillin, Procaine- penicillin				
Tetracycline	chlortetracycline, doxycycline, oxytetracycline				
Aminoglycosides	dihydrostreptomycin, gentamicin, kanamycin, neomycin, streptomycin				
Macrolides	tylosin				
Quinolones	enrofloxacin, norfloxacin, flumequin				
Sulphonamides	sulphonamide analogues and potentiators				
Polymyxins/polypeptides	bacitracin, colistin				
Nitrofurans	furazolidone, nitrovin				
Ionophores	monensein sodium				

*Dosage forms, Parenteral, oral solution/water medication, In-feed, Intramammary, topical, intra-uterine, ophthalmic/aural, Tablets/bolus, T-treatment, p, preventive & gp, growth promotion.

Appendix Table 2. Quantities of veterinary antimicrobials (antibiotics), tonnes of active ingredient used in food-producing animals by route of administration in Dar es Salaam, Tanzania, (2016-2018).

Route of administration	Antimicrobial class	2016	2017	2018	2016-2018
Topical	Aminoglycosides	0.1(6.7)	0.1(5.6)	0.1(4.8)	0.3 (5.6)
	Beta-lactam	0.3 (20.0)	0.4 (22.2)	0.6 (28.6)	1.3 (24.1)
	Polypeptides	0.0 (0.0)	0.0(0.0)	0.0 (0.0)	0.0 (0.0)
	Sulphonamide	0.7 (46.7)	0.8 (44.4)	0.8 (38.1)	2.3 (42.6)
	Tetracycline	0.4 (26.7)	0.5 (27.8)	0.6 (28.6)	1.5 (27.8)
	Total	1.5 (100)	1.8 (100)	2.1(100)	5.4 (100)
Oral	Beta-lactams	0.2 (0.5)	0.2 (0.5)	0.2 (0.5)	0.6 (0.5)
	Tetracyclines	19.6 (52.5)	22.6 (53.3)	21.3 (52.0)	63.5 (52.6)
	Aminoglycosides	2.3(6.2)	2.6(6.1)	2.5(6.1)	7.4(6.1)
	Macrolides	2.4 (6.4)	2.8 (6.6)	3.0 (7.3)	8.2 (6.8)
	Nitrofurans	0.9 (2.4)	0.8 (1.9)	1.0 (2.4)	2.7 (2.2)
	Quinolones	3.2 (8.6)	3.5 (8.3)	3.4 (8.3)	10.1(8.4)
	Polymyxins/polypeptides	1.6 (4.3)	1.8 (4.2)	1.7 (4.1)	5.1 (4.2)
	Sulphonamides	6.6 (17.7)	7.5 (17.7)	7.3 (17.8)	21.4 (17.7)
	Ionophores	0.5 (1.3)	0.6 (1.4)	0.6 (1.5)	1.7 (1.4)
	Total	37.3 (100)	42.4 (100)	41.0 (100)	120.7 (100)
Parenteral	Beta-lactams	3.5 (21.6)	3.8 (20.7)	3.4 (20.5)	10.7 (20.9)
	Tetracyclines	4.1(25.3)	5.0 (27.2)	4.3 (25.9)	13.4 (26.2)
	Aminoglycosides	3.4 (20.9)	3.8 (20.7)	3.4 (20.5)	10.6 (20.7)
	Macrolides	0.8 (4.9)	0.8 (4.3)	0.7 (4.2)	2.3 (4.5)
	Quinolones	0.4 (2.5)	0.5 (2.7)	0.4 (2.4)	1.3 (2.5)
	Sulphonamides	4.0 (24.7)	4.5 (24.5)	4.4 (26.5)	12.9 (25.2)
	Total	16.2 (100)	18.4 (100)	16.6 (100)	51.2 (100)

Appendix Table 3. Quantities of veterinary antimicrobials (tonnes of active ingredient) consumed by galenic form in Dar es Salaam, Tanzania (2016-2018).

Antimicrobial class	2016	2017	2018	2016-2018
Galenic in solid dosage forms (powder/bolus)				
Beta-lactams	0.2(0.6)	0.2(0.5)	0.2(0.5)	0.6(0.5)
Tetracyclines	19.7(57.1)	22.7(57.6)	21.4(56.2)	63.8(57
Aminoglycosides	2.3(6.7)	2.6(6.6)	2.5(6.6)	7.4(6.6)
Macrolides	2.4(7.0)	2.8(7.1)	3(7.9)	8.2(7.3)
Nitrofurans	0.9(2.6)	0.8(2.0)	1(2.6)	2.7(2.4)
Quinolones	0.1(0.3)	0.1(0.3)	0.1(0.3)	0.3(0.3)
Polymyxins/polypeptides	1.6(4.6)	1.8(4.6)	1.8(4.7)	5.2(4.6)
Sulphonamides	6.8(19.7)	7.8(19.8)	7.5(19.7)	22.1(19.7)
Ionophores	0.5(1.4)	0.6(1.5)	0.6(1.5)	1.7(1.5)
Total	34.5(100)	39.4(100)	38.1(100)	112(100)
Galenic in liquid dosage forms (suspensions/solutions)				
Beta-lactams	3.8(18.4)	4.2(17.9)	3.9(17.9)	11.9(18.1)
Tetracyclines	4.5 (21.8)	5.5 (23.5)	4.9 (22.6)	14.9 (22.7)
Aminoglycosides	3.5 (16.9)	4.0(17.1)	3.5(16.1)	11.0 (16.7)
Macrolides	0.8 (3.9)	0.8 (3.4)	0.7 (3.2)	2.3 (3.5)
Quinolones	3.5 (16.9)	3.9 (16.7)	3.8 (17.5)	11.2(17.0)
Polymyxins/polypeptides	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Sulphonamides	4.5 (21.8)	5.0 (21.4)	4.9 (22.6)	14.4 (21.9)
Total	20.6 (100)	23.4 (100)	21.7 (100)	65.7 (100)

Appendix Table 4. Trends of food- producing animal population included in quantitative data reported in Tanzania, 2016-2018.

Species	Year	Animal population	Number of animal slaughtered /year	Carcass weight (kg)	Live weight (kg)	Animal biomass (tonnes)
	2016	26935923	3177658	101.9	181.9	4899644.4
Cattle	2017	26519776	3121863	126.4	225.7	5985513.4
	2018	27282702	3204778	147.2	262.9	7172622.4
	2016	5751090	1566343	12.0	25.5	392956.3
Sheep	2017	7332299	2001054	12.0	25.5	500896.6
	2018	7945775	2172878	12.0	25.5	542697.6
	2016	18779631	3590171	12.0	25.5	1320513.1
Goats	2017	18017462	3428777	12.0	25.5	1267304.6
	2018	18497912	3504103	12.0	25.5	1301492.8
	2016	515901	369584	39.9	51.2	27837.4
pigs	2017	518023	371415	40.0	51.3	28005.0
	2018	520853	373757	39.9	51.2	28136.6
	2016	37272000	15871000	6.5	8.3	309357.6
Chicken	2017	37518000	16000000	3.9	5.0	187590.0
	2018	37992000	16121000	4.8	6.2	235550.4